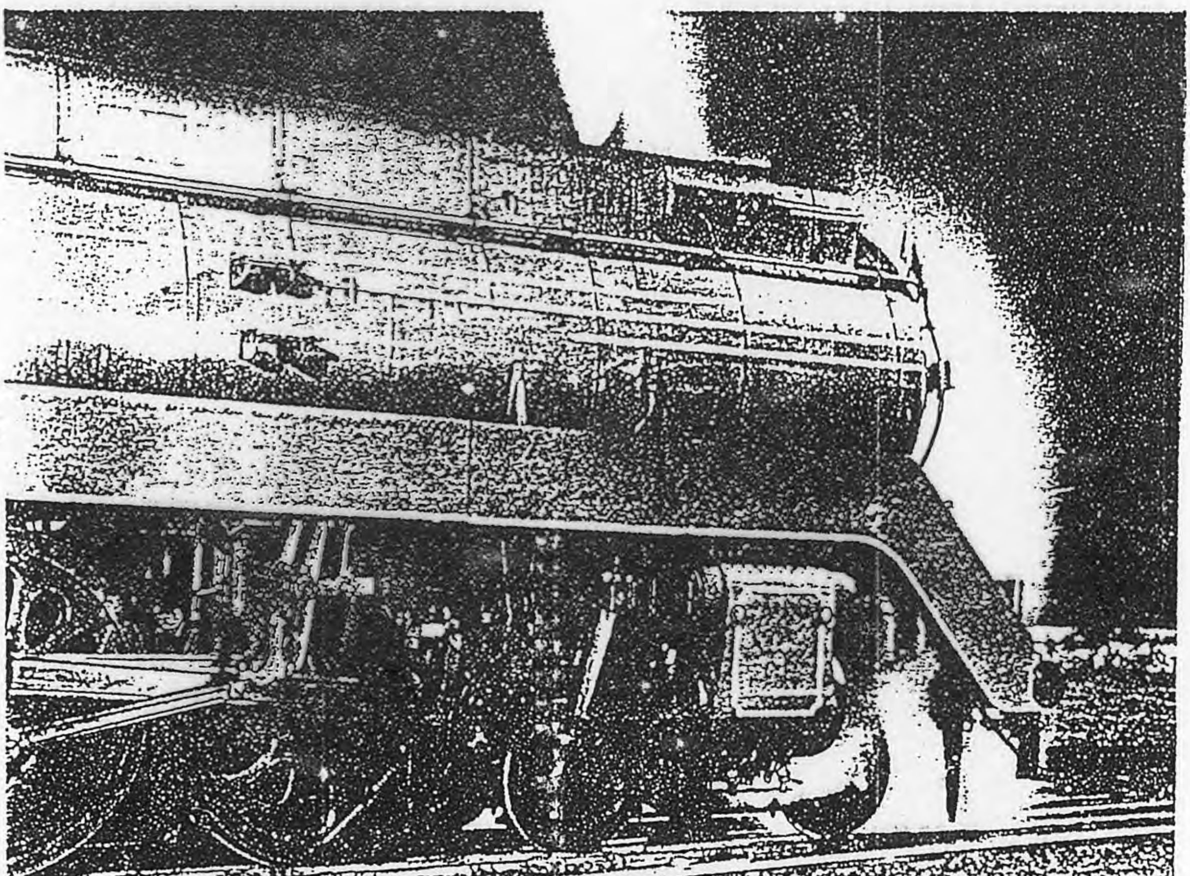
Locomotive 3801

Historic Engineering Marker



Engineering Heritage Committee
Sydney Division, I.E. Aust. 1993

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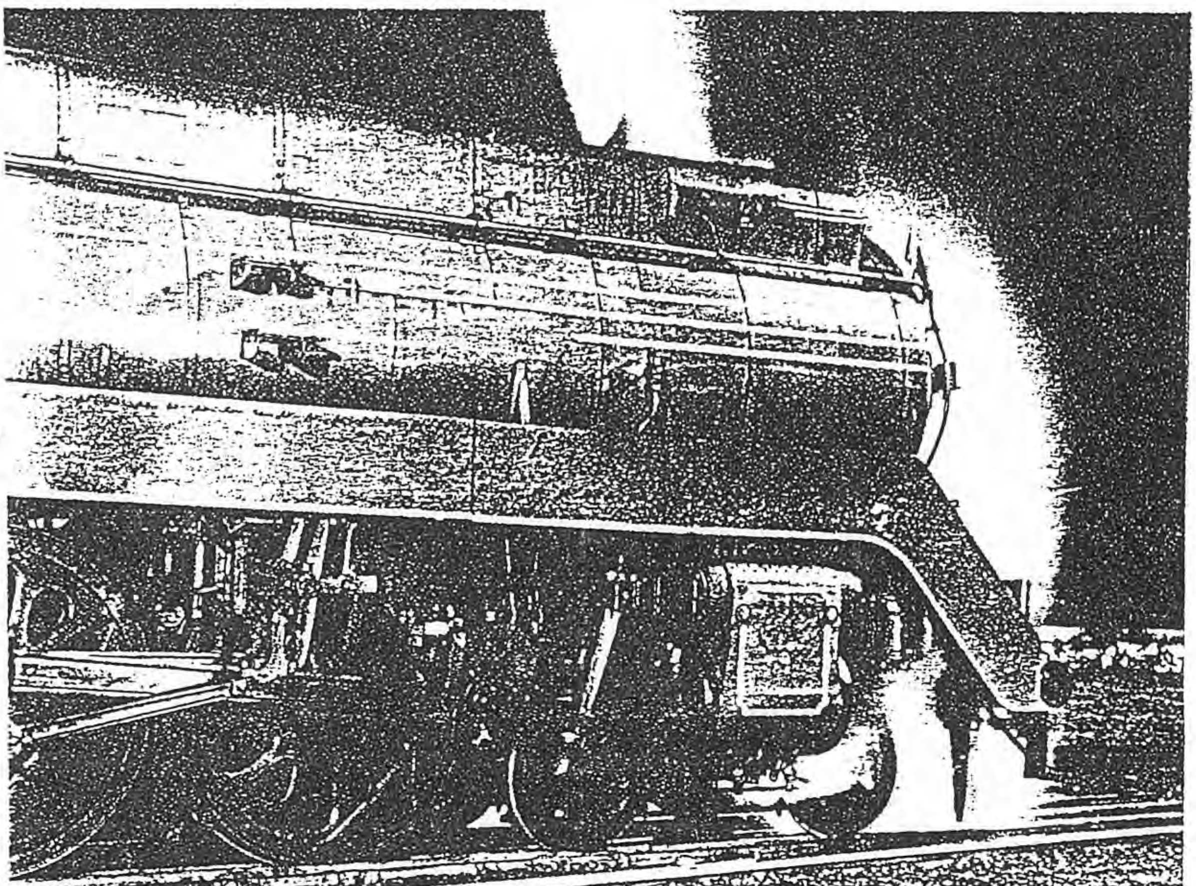

Engineering Heritage Committee
Sydney Division, I.E. Aust. 1993

Commemorative Plaque Nomination Form

To:
Commemorative Plaque Sub-Committee
The Institution of Engineers, Australia
11 National Circuit
BARTON ACT 2600

Date: July 1993

From: Sydney Division

(Nominating Division or Branch)

The following work is nominated for an *Historic Engineering Marker/National Engineering Landmark award:

Name of work: Locomotive 3801

Location, including address and map grid reference if a fixed work: Eveleigh Workshops NSW

Owner: 3801 Ltd

In support of the nomination the following information is provided:

For an Historic Engineering Marker (HEM)

(1) Proposed wording on HEM#

See Attachment

(2) Justification - please make data as complete as possible.#

For a National Engineering Landmark (NEL)

(1) Date of construction (or other significant dates).

(2) Names of key professional personnel associated with the work.#

(3) Historic engineering significance of the work.#

Statement of Significance

Locomotive 3801 was the first of a class of steam locomotives that led to a faster and more efficient express train operation in NSW from 1940 to 1960. It is also the last remaining example. The design and construction was Australian and included many innovative features. it was the first streamlined locomotive in NSW and represents the final development of express steam locomotives in this State.

I.E. Aust
Crest

Locomotive 3801

Locomotive 3801 was constructed in 1943 to the design of the engineering staff of NSWGR and constructed in Sydney by Clyde Engineering. It introduced many innovative features and had the highest boiler pressure used on steam locomotives in Australia. The design led to the development of faster and more efficient express train operation from 1940 - 1960. During its service it operated all major express trains in NSW and holds the Sydney - Newcastle speed record for steam trains.

3801
A Legend in Steam

By R G Preston
ASTC, P.Eng, MIE Aust, MCIT, JP

3801

A LEGEND IN STEAM

by
R.G. PRESTON
with
I.K. WINNEY
and artwork
by
Kenneth G. BOWEN

3801 Limited

ıor
?R INTO TANK
- IN STEAM
:ARS OF THE SYDNEY TO PARRAMATTA RAILWAY
EAT NORTHERN RAILWAY
ARDS IN STEAM - THE 30 CLASS
DARDS IN STEAM - THE 32 CLASS
ARDS IN STEAM - THE 50 CLASS
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First published
in 1992 by
3801 Limited

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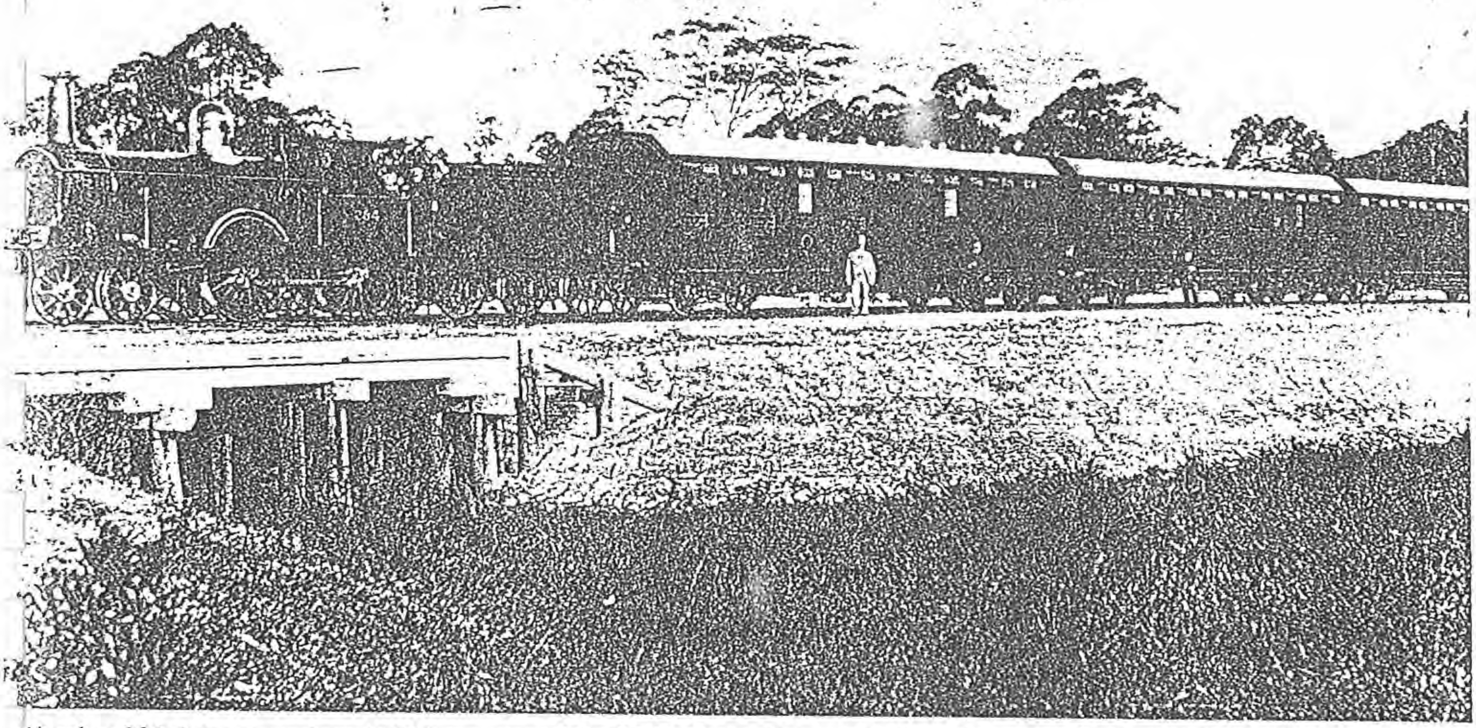


Number 284, later renumbered 1624, was one of the D261 class which was built by Dubs and Co. from 1883. They featured driving wheels six feet in diameter, the largest ever applied to a NSW locomotive. The 4-4-0 pauses to pose with a rake of side-loading "express lavatory" cars, the latest in passenger accommodation, on their delivery run from the manufacturer.
Photo: State Rail Archives

These efficient machines were employed on the important expresses of their day and were used to haul the express and mail trains on the ever-expanding system. Towns such as Tamworth and Wagga Wagga were first served by passenger trains hauled by these 4-4-0 engines. In all, 68 were built to the design, the last entering service in 1882 and can be considered the first really successful express locomotives.

Lasting until 1962, the Z12 class can still be seen in museums, 1210 at Canberra, 1243 in the Power House Museum and 1219 at Thirlmere.

Later in 1877, an American 4-4-0 was placed in service to compare the American designs of the period with those of British origin. U105 was the engine concerned and while a sister engine was imported two years later, the English tradition was followed. However, the U class did enter into the working of express trains, the 5'3" (1 600 mm) driving wheels allowing a good turn of speed.

It should be mentioned at this point that 50 mph (80 kph) was the speed limit at this time although there was no way of verifying the adherence of drivers to the limit.

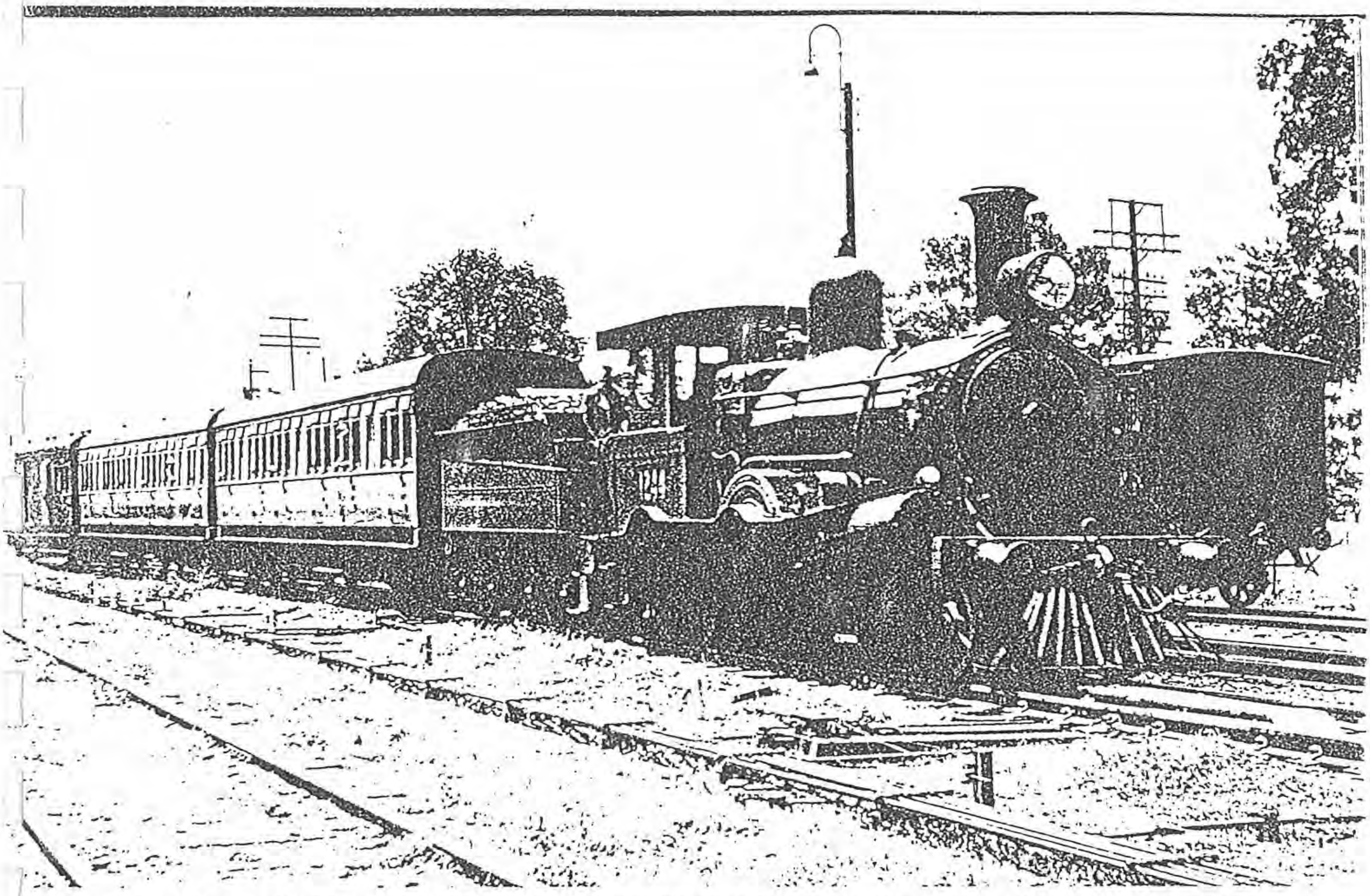
We now come to a most significant group of engines with three different variations and two different builders involved.

In 1882, Beyer, Peacock of Manchester, England, constructed the six 255, later D255 and eventually Z15 class. With driving wheels 6 feet (1 828 mm) in diameter, they were typical 4-4-0 express engines of the time and would not have been out of place on any English main line.

Their tractive effort was 12,400 lbs (55 155 N) but they had a better turn of speed than their predecessors and reports of them running at 70 mph (112 kph) at a time when such speeds were not considered, are on record. The age of speed in express train working had truly arrived.

Encouraged by the performance of the 255 class, the authorities ordered 24 generally similar engines but with the same tractive effort as a 79 class. The Glasgow firm of Dubs & Co. won the contract and they entered service in 1883. In time they were reclassified as the D261, later Z16 class to separate them from their Beyer, Peacock sisters. Two variations were included in a repeat order for 17 otherwise similar 4-4-0s. Dubs again won the contract and supplied the 334 class in 1884. They had a tractive effort between the two previous batches and featured a leading bogie with a longer wheelbase presumably to improve their stability at speed. Despite these differences, they were grouped in the Z16 class in 1924.

All these 4-4-0s were used on the Melbourne Express from its inception in 1883 and operated other important trains. Some were sent to the then isolated Northern section based on Newcastle and hauled the mails and expresses to Armidale and Tamworth. The introduction of larger engines in 1892 stole many of their star turns but they maintained the express train tradition for many years. Most were withdrawn in the



The 79 class 4-4-0s were introduced from 1877 and were reclassified first C class and then 12 class. Once their express train duties were taken by larger power, they passed to branch line passenger work. A train from Temora rolls into Cootamundra in 1949 with two side-loading cars and a PHG brake van, usually found at the rear of goods trains. *Photo: Ken Winney*

years around 1930.

Another venture into the 4-4-0 passenger theme came in 1887 when the Vulcan Foundry-built 373, later H373 and Z17 class entered service. These twelve engines had greater tractive effort than any predecessors in an attempt to work heavier loads over the mountains. They had the same size driving wheels as the C79 class with whom they shared many duties.

William Thow who, as Chief Mechanical Engineer, assumed responsibility for locomotive design in 1890, expressed his intention of following a four-coupled driving wheel policy just as his predecessors had done. A visit to England showed him the need to change his thinking to cope with the traffic now offering as well as with the terrain to be conquered. From this time, New South Wales was to use six-coupled engines for its express trains and the first of the five successful designs arrived in the form of the P6 class in 1892.

The need for more powerful locomotives was not hard to understand. While some grades had been eased, many 1 in 40 inclines remained and they were most inconveniently situated. In one report, the Commissioners lamented that all main line traffic had to pass over such grades. The carriages in use had increased both in comfort and size. Coupled with the longer trains being operated, there was an urgent need for more powerful locomotives if double heading was to be minimised.

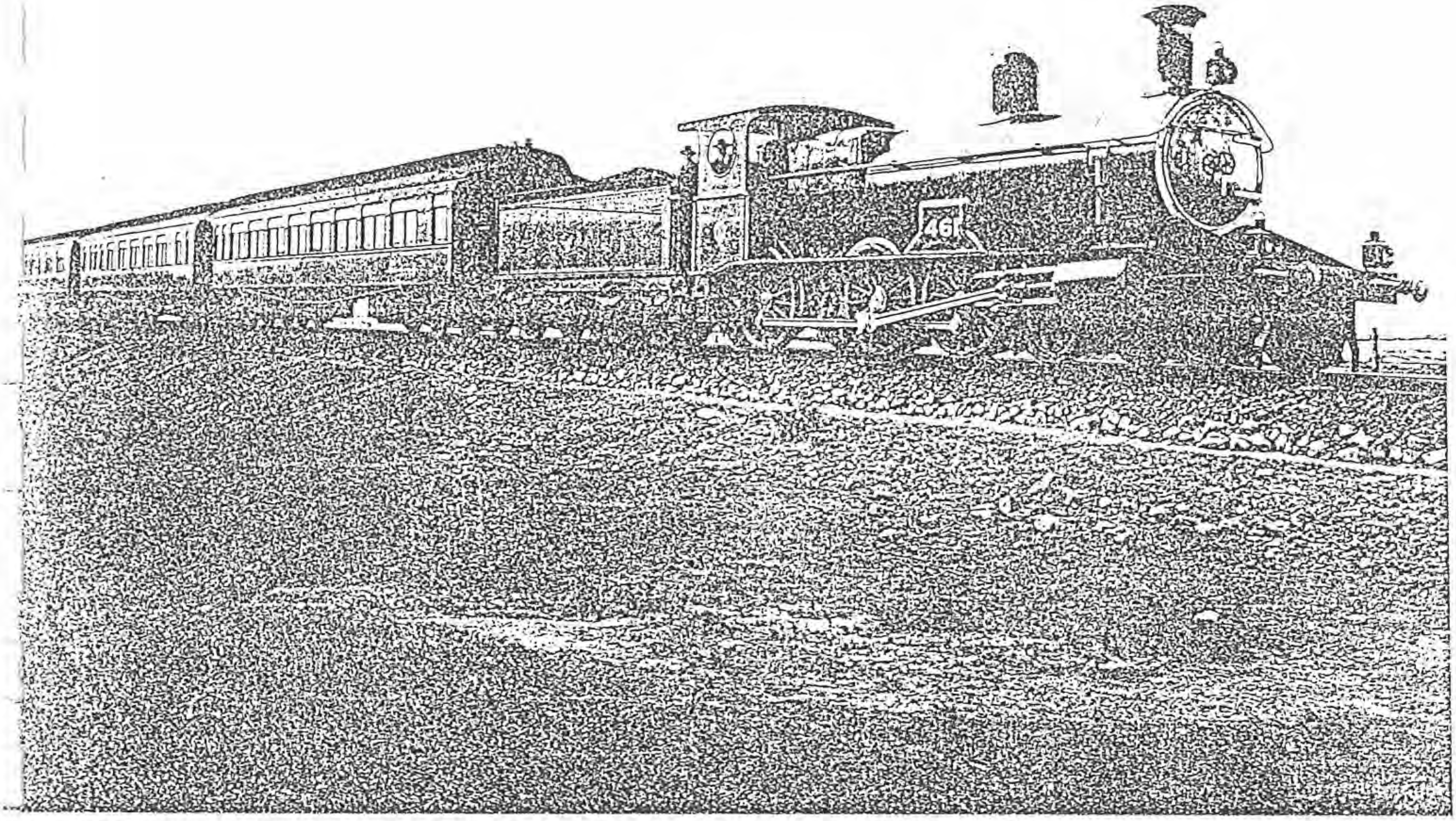
This need was more than ably met by the P class. To meet the weight limitations which the track structure imposed and to obtain the tractive effort needed to haul the trains, driving wheels 5 feet (1 524 mm) in diameter were used. While this did limit their top speed, the new engines more than compensated with the rate at which they overcame the grades. In the design of the new 4-6-0s, a tractive effort of 26,000 lbs (115 648 N) had been possible. Doubleheading of D class was common on the Melbourne Express but, with the introduction of the P class, one loco now generally sufficed. In time, 191 were placed in service, such was the success of the design.

As the C32 class, these locos lasted almost to the end of the steam era and were used on a wide variety of goods as well as passenger turns. They operated mail and fast passenger trains throughout the system until displaced by diesel electric locos from the late 1950s.

In practice, their smaller driving wheels did not limit their speed unduly and many a journey included sections run at the speed limit of 60 mph which became the norm as track conditions improved.

The combination of power and speed made them ideal to add to the front of expresses with extra cars added and many 32 class have assisted 3801 and its family climb the steep grades when the load was heavy.

From the introduction of the P class, all future express



A suitable location was chosen to photograph the latest clerestory roof cars built in 1905 to enhance accommodation on the Melbourne Express. The train was headed by No.461, later 3210, one of the 191 strong P6 class 4-6-0s which took over express trains from 1892. *Photo: State Rail Archives*

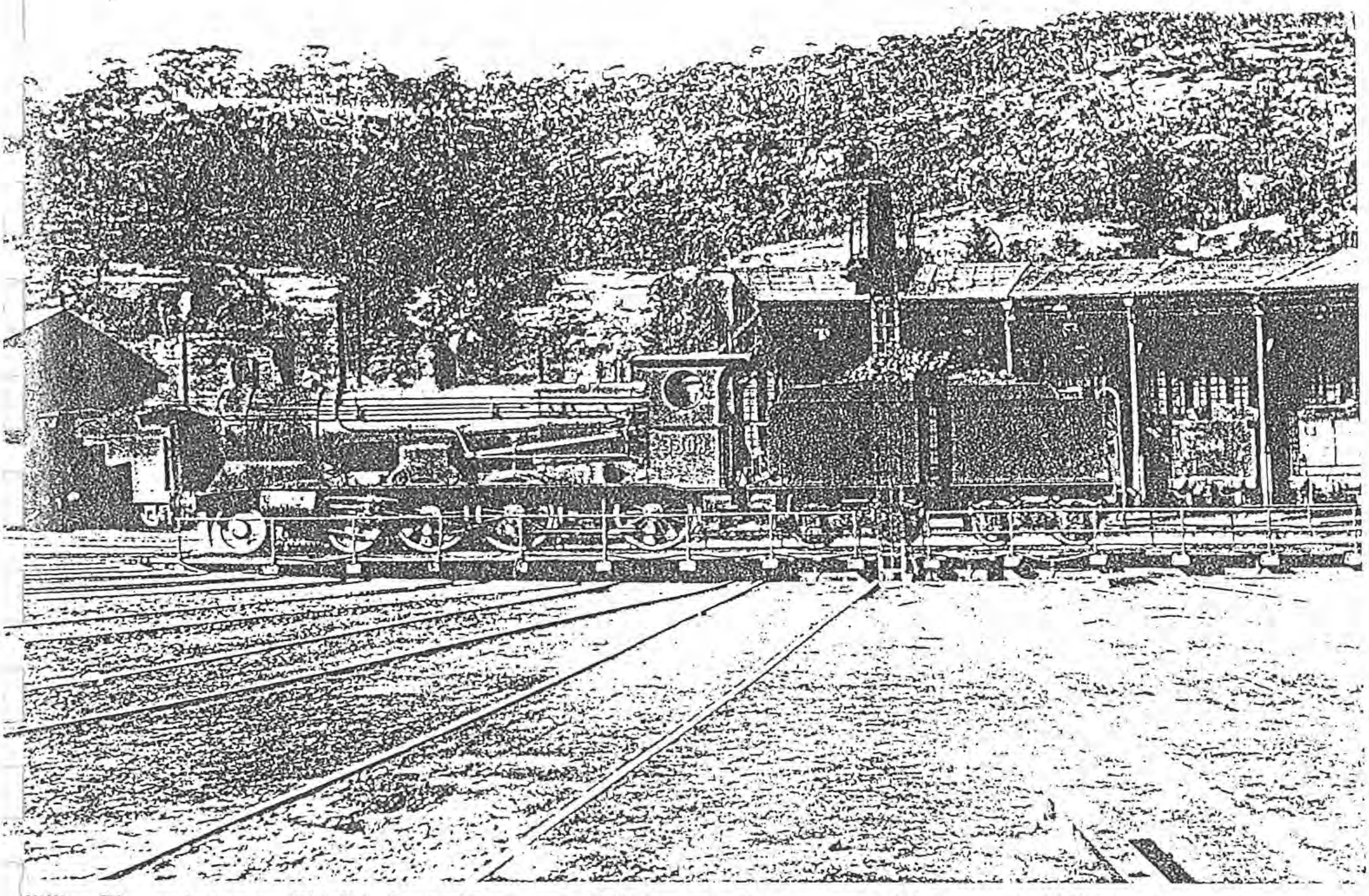
power was to have six driving wheels. Thow tried to make amends for the smaller driving wheels on these locos by designing a version with 5'9" (1 752 mm) drivers. These N class first appeared in 1909 and were, to all intents and purposes, a P class with 5'9" (1 752 mm) driving wheels. In practice, the need for this refinement was not necessary and only five of the N class were built and the P class continued to grow in numbers. Thow had great faith in the Railway's own workshops and the task of constructing the N class was given to Eveleigh Works. A new tradition was thus founded and from this time, all new contracts for steam passenger power were built in the New South Wales and, where possible, in the Railway's own shops.

One problem experienced with the N class was a tendency to give a rough ride at high speed and their use on express trains declined in consequence. Reclassified as the C34 class in 1924, they finished their days at Junee and doubtless watched in envy as the 38s sped past with the expresses.

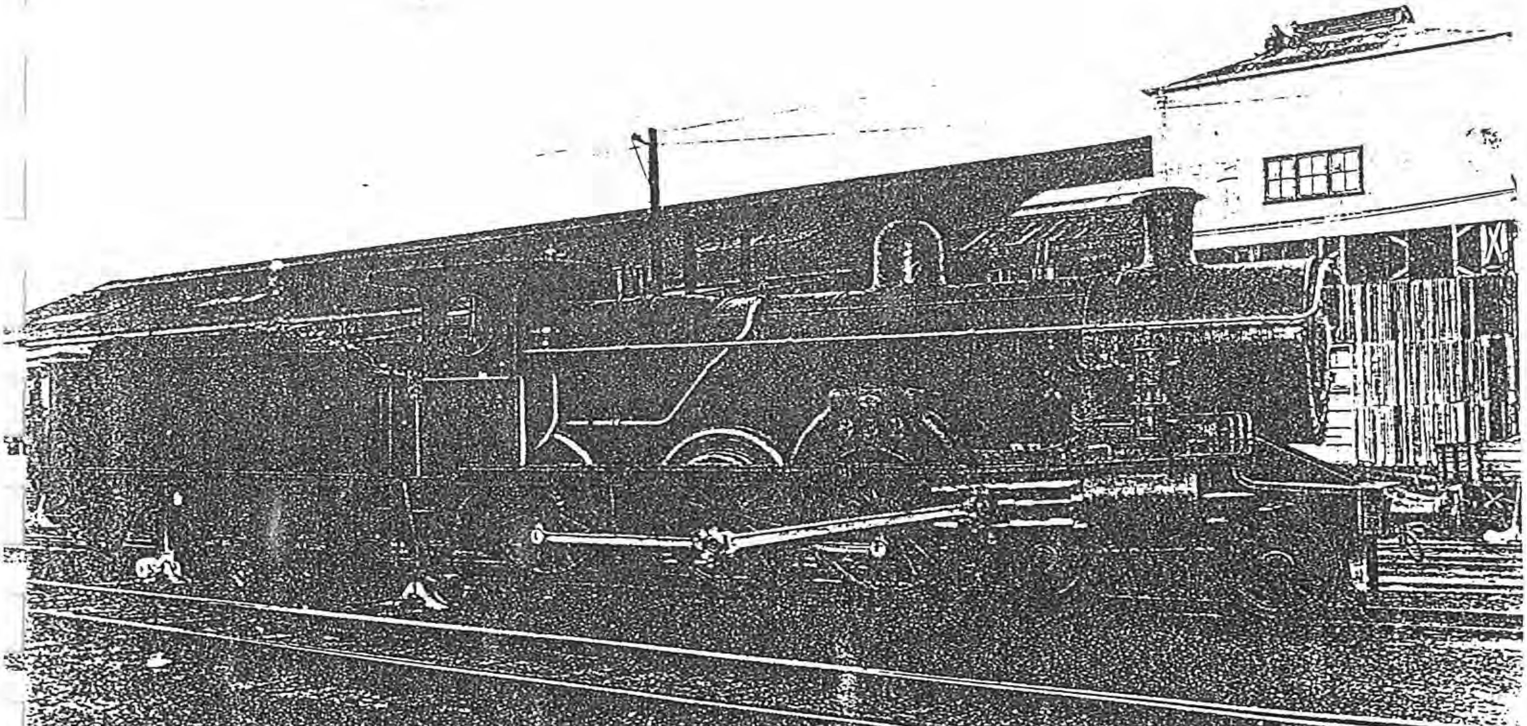
Thow retired and in his place as CME came Mr. E.E. Lucy. At this time, track conditions on the main lines were improving and higher speeds by heavier locos was possible. More power was also needed as traffic continued to grow with consequent increase in train weight. Sleeping cars were popular and bigger and heavier vehicles were being built. Lucy set to the task of providing new locomotives to meet the challenge and fell back on his experience with the Great Western Railway of England.

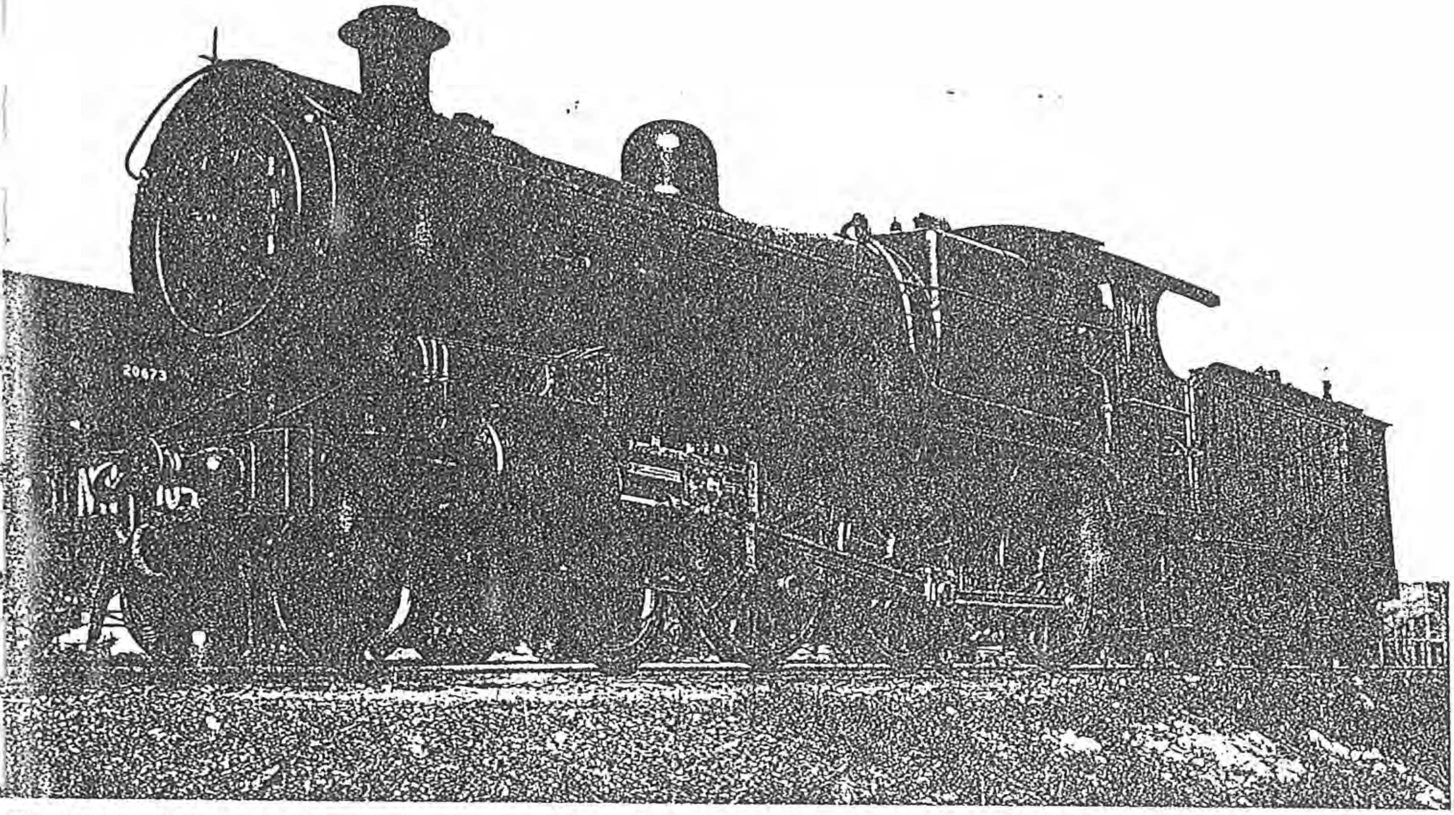
The result was a batch of fine 4-6-0 locos which featured 5'9" (1 752 mm) driving wheels and a tractive effort of 29,200 lbs (129 881 N) and which were identified as the NN class. Again Eveleigh Works produced the order and thirty entered service between 1915 and 1917. A further five were produced in 1923. Their weight imposed some limitations on the scope of their operations but most expresses felt the benefits of their capacities. They acquired the nickname "Nannies", a derivation of the NN categorisation.

Rebuilt from about 1940, the class was known as C35 in the later numbering scheme and were concentrated at Broadmeadow Depot for their latter years. It was at this station that the 38 class handed over their North Coast and Main North expresses and mails to lighter power such as the 35 class who shared in this role until diesels displaced them.



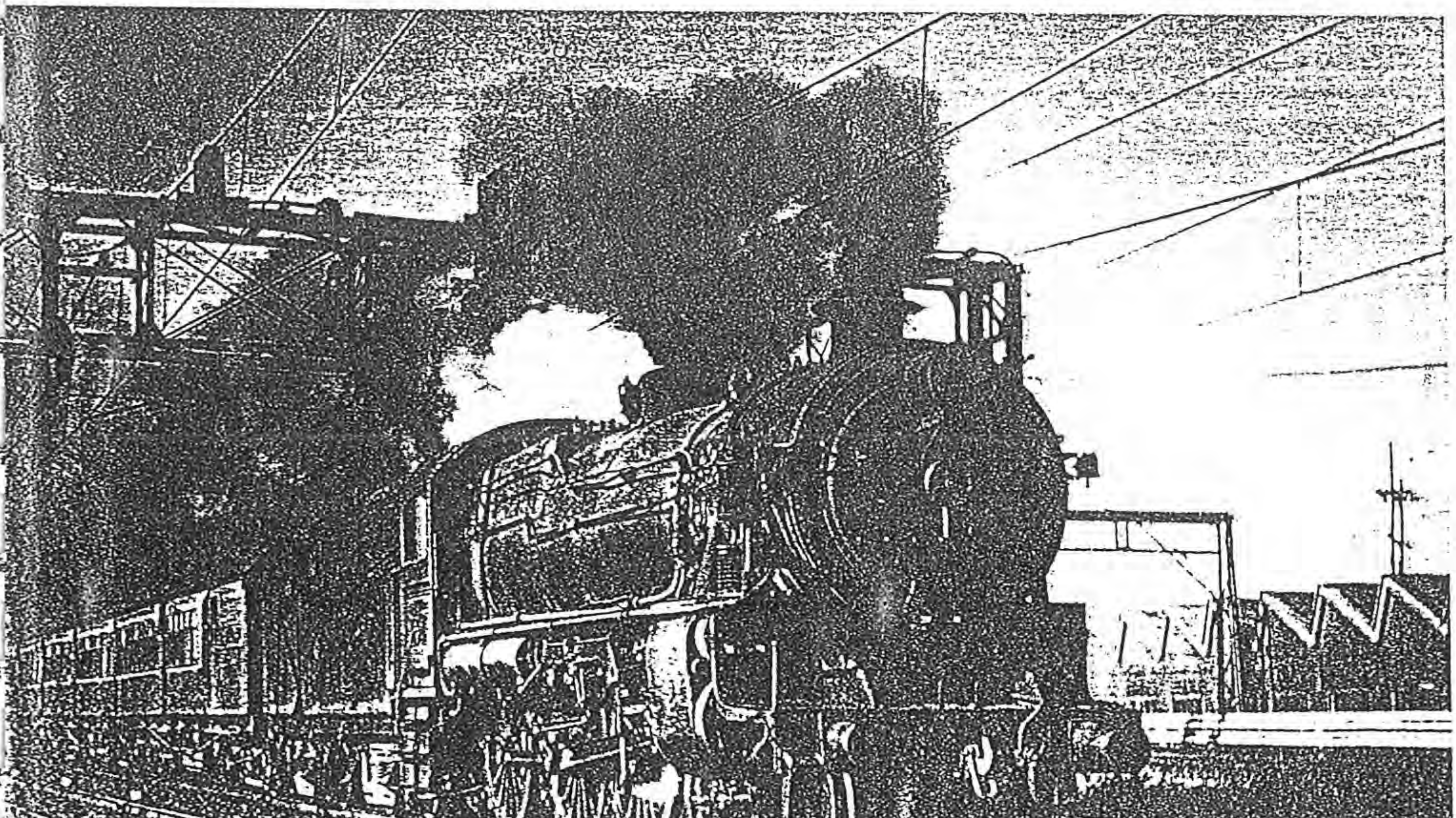
Villiam Thow, who became Chief Mechanical Engineer in 1890, introduced two express 4-6-0 designs, the 1892 P6, subsequently 32 class, and a variation, the N928, later 34 class, in 1909. Lithgow turntable slowly rotates 3308 in 1957 (above) while Eveleigh is the setting for No.932, ultimately 3405, in the photo below. Photos: Ron Preston and State Rail Archives





The 4-6-0 tradition was maintained in the next two designs of express power. The NN 1027 class (above) first appeared in 1914, No.1041 being renumbered 3515 in 1924. To speed their progress over single-line sections, the 35 members featured staff exchanging apparatus which was mounted initially in a recess in the cab side. The 36 class dated from 1925. A Lithgow-bound passenger steams towards Homebush in 1956, rebuilt 3664 (below) providing the power.

Photos: State Rail Archives and Ron Preston



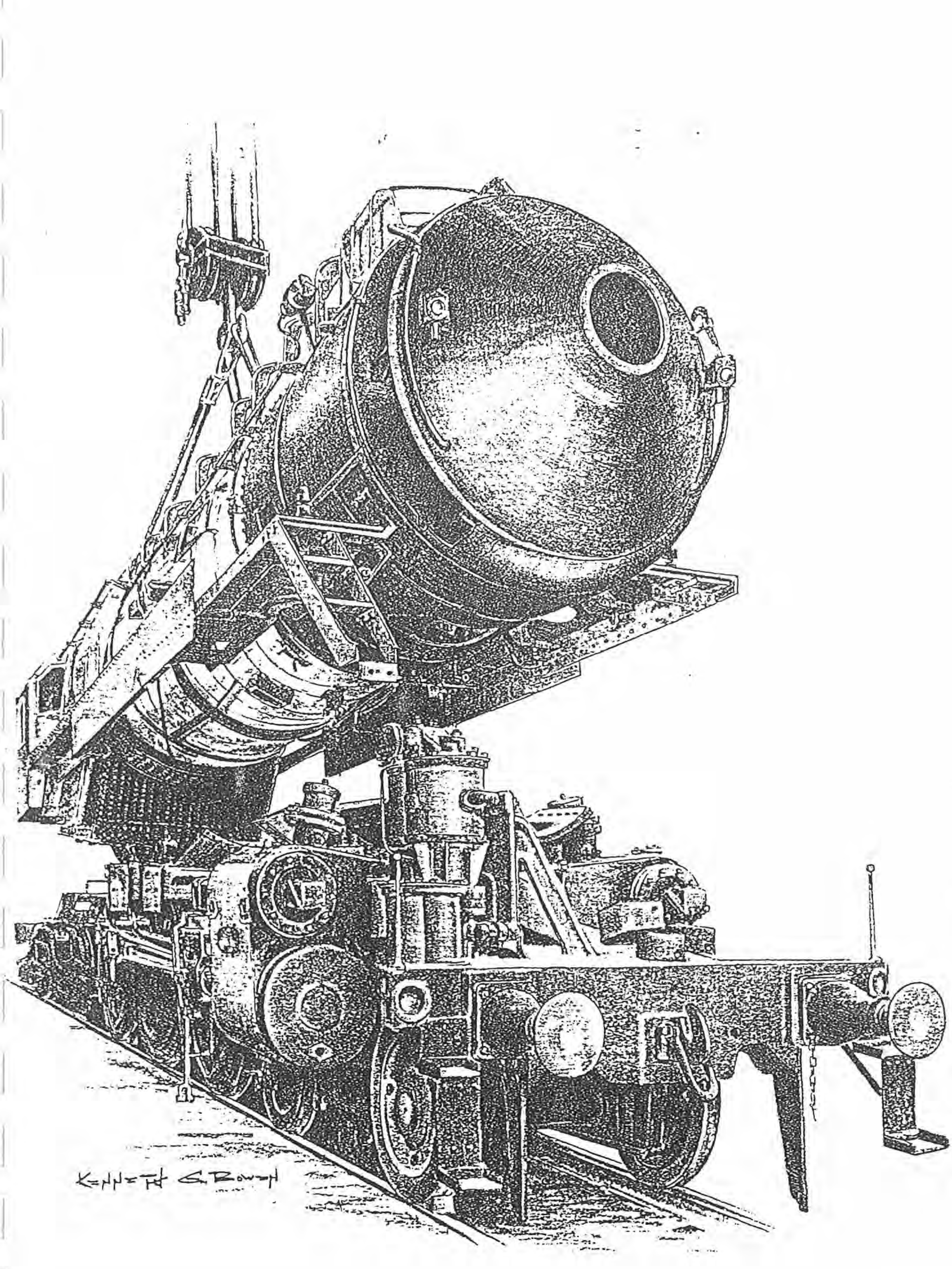
(hen first introduced to service, the 75 members of the 36 class were fitted with round-top boilers and featured green paint. Several were named and allocated to specific trains. Such was 3608, "Hawkesbury", which hauled the red and cream clerestory oof sets to and from Newcastle. The 4-6-0 rounds the curve out of Strathfield on its way north in 1935. *Photo: C. Haydon*

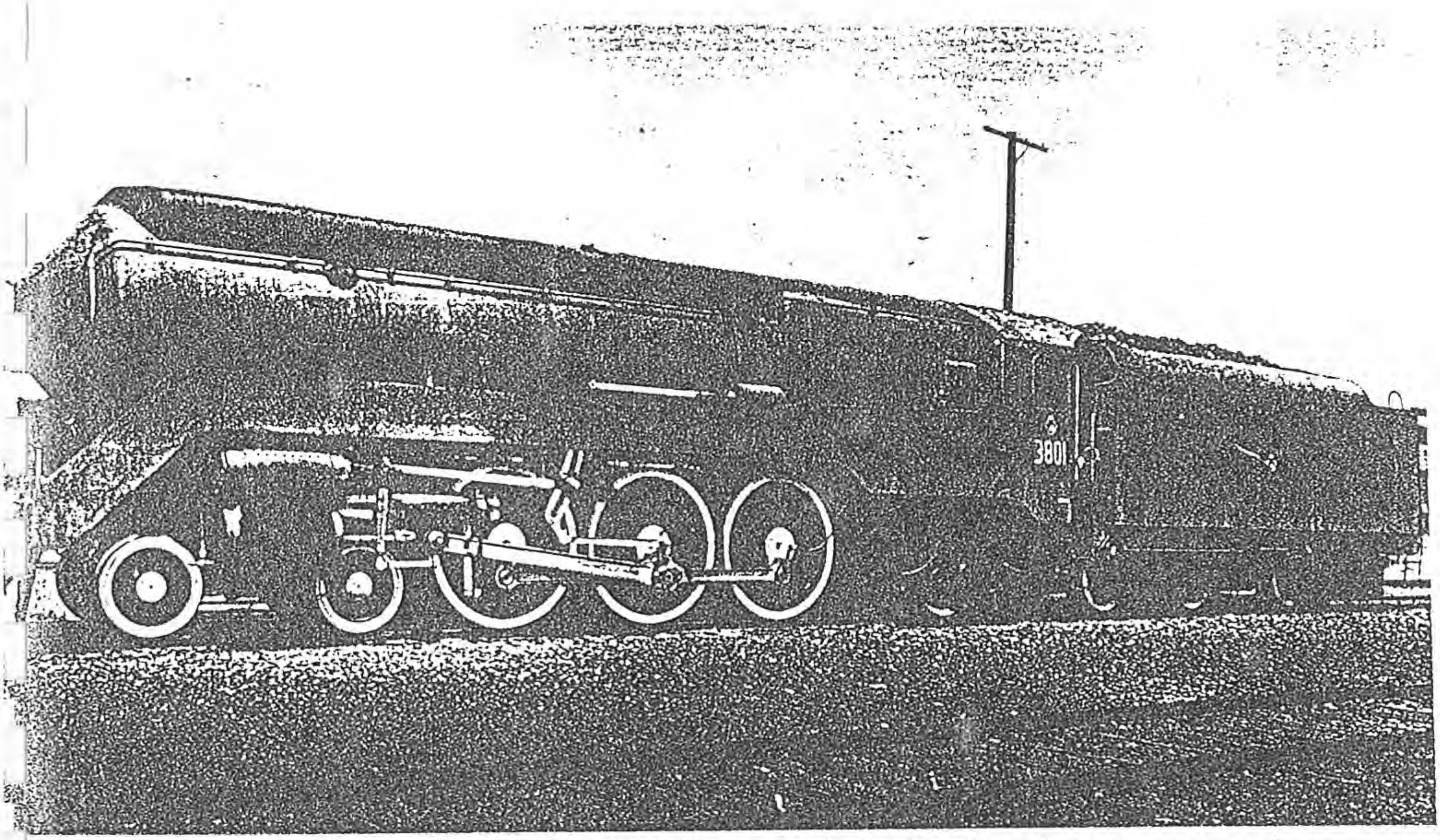
As the economy of the Nation grew, so the volume of raffic handled by the Railways increased. Travel within the ate was handled by fast passenger trains planned to travel s much as possible in daylight while mails, parcels and necessities of country life were sped overnight to country owns by mail trains. These trains were a convenient means or commercial people and travellers to visit "the bush" and for country folk to reach the city. Sleeping as well as sitting cars were provided and these trains continued to grow in eight as well as in number.

More motive power was required and this need was met from 1925 by the introduction of 75 4-6-0 express engines. nitially coded NN2 to indicate their improvement on the NN lass, the engines entered service with the 1924 style numbering and were universally known as the C36 class. Their ractive effort of 30,500 lbs (135 664 N) gave them more aulage power than the 35s but the same size driving wheels s their predecessors was again used.

In service, the "Pigs", as they were nicknamed, took over ll the more important runs, a duty they continued to perform until the introduction of the 38 class. They continued to operate many fast runs in conjunction with the 4-6-2s almost to the end and were rebuilt with Belpaire boilers from 1953 to help them continue in this role.

For a time, the Depression of 1930 took its toll on the economy and on the traffic which had to be moved. Consequently, many of the earlier express engines passed into history at this time. However, after every downturn comes a recovery and by the late 1930s, the increase in passenger business was creating fresh demands on the motive power fleet. Thus the stage was set for the introduction of arguably Australia's most famous class of steam locomotives. In setting out to meet these demands, the New South Wales Railways looked to the same design team that had produced the previous classes and whose experience had been well founded on over seven decades of express train operation. All the mechanical problems that had been overcome, all the operating difficulties that had been met now formed the basis for a design that would give the NSWGR its finest hour in steam locomotive engineering.


KENNETH G. BOWEN



Clyde Engineering Builder's Number 463, 3801, poses in its plain grey livery shortly after delivery. At the time, a speed indicator was fitted and took its drive from a gearbox attached to the rear crank pin. *Photo: State Rail Archives*

CONSTRUCTION

The success of New South Wales passenger train operations using the express steam locomotive fleet can best be demonstrated by watching the growth of the business. In 1877, the start of the era of the C class 4-4-0s, just under three million passengers were carried during the year. The system at the time reached out a total of 598 miles.

By 1892, the year of the 4-6-0 P class, just under 20 million people paid their fares to a system that extended 2185 miles.

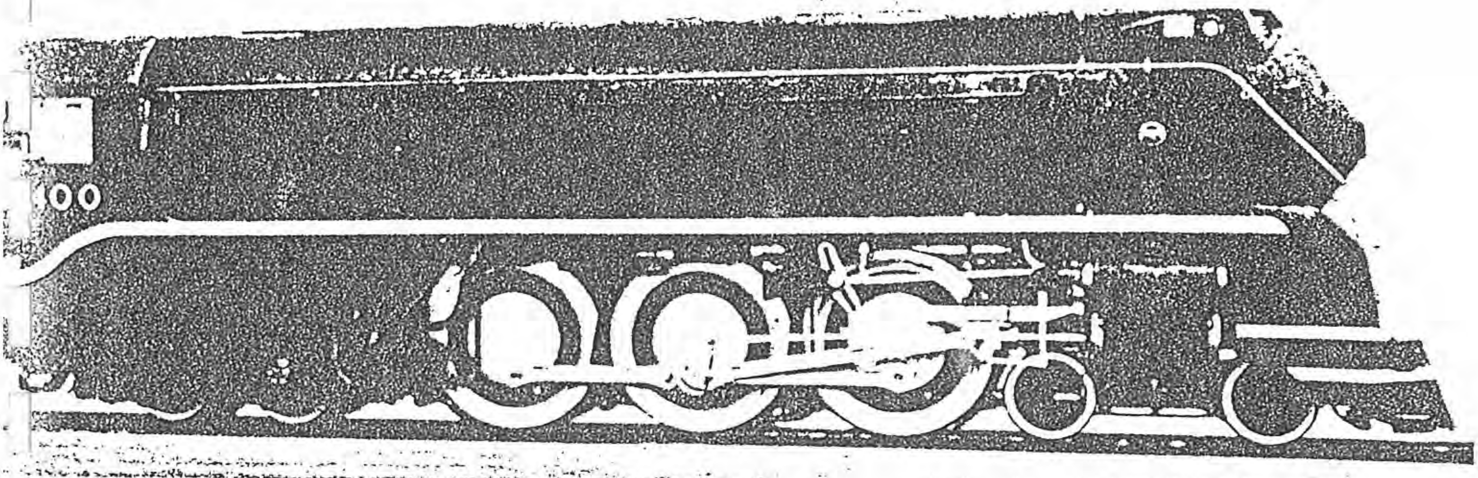
When the NN class came on the scene in 1914, 86 million journeys were recorded over the 3968 miles of track which had been opened. Despite the war, the growth pattern continued and 131 million customers awaited the 36 class in 1926 and the trains which ran on the 5742 miles of railway available.

Even after the negative effects of the Great Depression, business in 1938 accounted for just under 190 million journeys. True, many of these were on the electrified suburban network, but country travel was keeping pace with the development of the system which now extended to 6114 miles of line. With the prospect of further growth, the time was right to introduce bigger and even more powerful locomotives. Another factor which made improvements necessary was the development of road transport and the Railways had to match the convenience of the new mode if they were to maintain their share of the market.

The Annual Report for the financial year ending 30 June, 1938 was full of initiatives to improve the passenger business. Some timetables were accelerated, additional services including mail trains were scheduled while the cars for the South Coast Daylight Express were "remodelled". Better facilities for booking seats and sleeping berths were provided and new "De Luxe" sleeping cars were placed in service on the Melbourne Limited Express. "A vigorous programme of improving country services has been pursued" the report went on and fifty new steel corridor cars were added to the fleet. The interior of many older cars was improved and "a total of 3,614 new photographs" were placed in cars to update their interiors.

What was needed now was a modern locomotive to not only speed these trains to their destinations, but also to add flair and style to the service.

New South Wales was not the only state that was actively wooing passengers and improving its services in ways that had never before been contemplated. South of the Murray, Victorian Railways were leading the drive by introducing the famous "Spirit of Progress" train with which the NSW's Melbourne Expresses interchanged passengers at Albury. Not only were the cars of this new train air-conditioned, but also the S class Pacifics that whisked it through Victoria were changed to make them look fast and powerful. They were



'e design of the streamlining used on the first five 38 class was based on the New York, New Haven and Hartford I-5 class -4 express passenger engines. Built by the Baldwin Company in 1937, these American locos shrouded their lower front to further smooth the flow of the passing air. With the need to retain buffers and hook draw-gear, the 38 class had to forego this refinement.

Photo: Baldwin Locomotive Works and State Rail

streamlined!

They were not alone in this field and the South Australian ilways had introduced their 620 class in 1936. These too were fast 4-6-2s and some featured streamlining.

Even Tasmania was employing the glamour of air smoothing and two R class were shrouded in a style not unlike the ctorian S class.

As early as 1922, the then Chief Mechanical Engineer, r. E.E. Lucy had prepared a design for a 4-6-2 locomotive, own as a Pacific type, but had settled for a 4-6-0, the 36 class. These engines were not without problems and consideration was given to rebuilding them with a two-wheel trailing truck. While this was never carried out, the possibility of more 36 class in either original or rebuilt form was always in the minds of the mechanical management.

Finally, in July, 1938, orders were given to prepare a sign for a Pacific locomotive and the Mechanical Branch Design Office was given the task.

By October of that year, the proposals had reached an vanced stage and preliminary details were sent to the General Steel Castings Corporation of America with the request that a design for a cast frame be prepared.

The decision was taken that the new locomotive was to ve style as New South Wales could not afford to let the southern states have the upper hand when it came to presentation. On 28 October, the Designing Engineer wrote to Kendll. Knight and Co. asking them "to obtain copies of details of steel clothing and smoothing" of the 4-6-4 I-5 class that the famous American locomotive company, Baldwin, had built r the New York, New Haven and Hartford Railroad.

New South Wales, too, was to enter the glamorous world f streamlining!

In December, a contract, identified as 12/38, was let to the lyde Engineering Company of Granville for the manufacture of five express passenger locomotives even though the final drawings were still not complete. It appears that the Government requested that the contract be allocated to Clyde "to relieve unemployment" as a matter of urgency. Not only was the final design incomplete, tenders were never called and other usual preliminaries were "set aside" such was the hurry. All that was available to Clyde was a specification and a side elevation outline drawing. From these rudimentary details, Clyde prepared a quotation. The price estimated was £99,225 ($198,450) for the five locomotives complete, except for the fitting of the brick arch in the firebox and the testing of the locomotives in steam. In addition, all tooling and jigs, patterns and gauges used in the manufacture were to become the "property of the Railways" at the conclusion of the contract. As Clyde had constructed 445 engines for the NSWGR before, there was no doubt that they had the experience and expertise to carry out the task and this alone was justification for the decision.

The annual report for the 1938/39 financial year announced that "Five new express passenger locomotives, larger and approximately 20 per cent. more powerful than the 'C36' class ... are being built locally for the Department by the Clyde Engineering Company Ltd." The locomotives were "calculated to give greater efficiency on heavily graded main lines, increased availability and reduced operation and maintenance costs."

On 22 December, 1938, the General Steel Casting Corporation responded to the order with their design for the cast frame and the planning of the incidentals which depended on this major component could then proceed. The proposal also outlined ideas to use Boxpok driving wheel centres. Time was taken to finally assess the proposed frame and the final details were despatched the following November.

The contract got off to a bad start. Boiler barrel plates of the size required were not rolled in Australia and thirteen months were lost in manufacturing the boiler in having to wait while the steel was imported.

The drawing listed the new locomotives as class C38, the

ass number 37 being left vacant in the locomotive numbering system for either more 36 class or for any variation such as rebuilding of those 4-6-0s.

As drawings of various details and components were finished and came off the boards, they were supplied to Clyde.

A major development, not only for the 38 class, but also for the world now intervened and the implications of World War II would cause many problems for the five engines.

There were even problems from within and the Commonwealth Bank Board, who monitored the importing of products that could be made in Australia, wrote asking that the cast steel leading bogie and trailing truck and wheels be built by the local firm of Bradford Kendall. As these had never been cast in Australia, the Railways responded that they would be cast by the General Steel Casting Company. Bradford Kendall could get into the act later. The battle raged and the Bank won, Bradford Kendall being awarded the order.

At this stage, the Americans were not heavily involved in the war and all five cast engine beds were speedily cast and shipped to Sydney, the first being received in February with the last two arriving on 18 June, 1940.

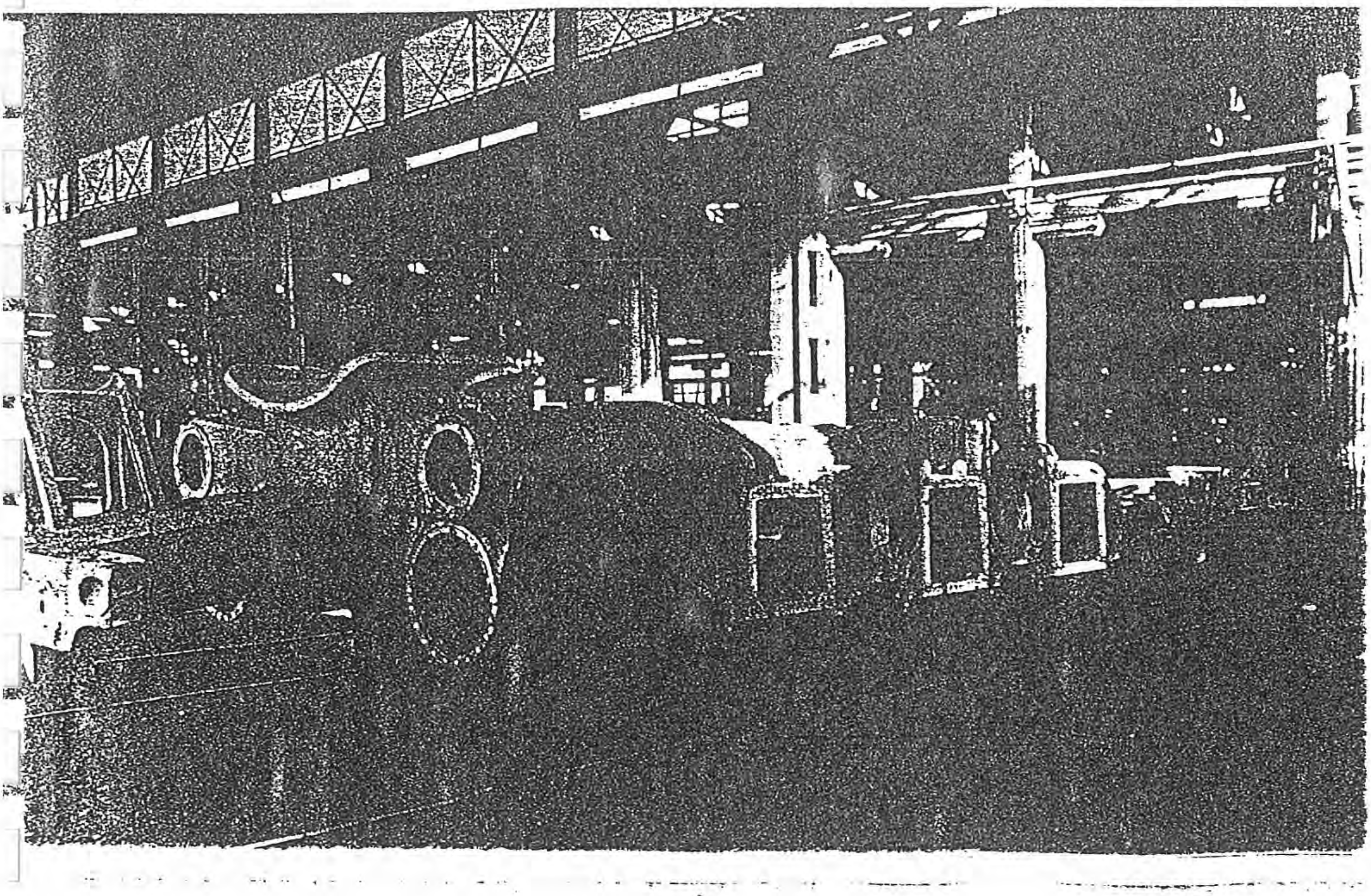
The roller bearings for the locomotive axles were a different proposition, however, and grave doubts existed on the ability of the S.K.F. Company to be able to ship them from their factory in Sweden to Sydney. Germany was at war with most of Europe and had set up a shipping blockade to stop help reaching Britain from America. The movement of the bearings had to be considered and, with Hitler's submarines active in the Atlantic, the route which would usually have been taken, another way had to be found. Finally, it was decided to surrepticiously ship the bearings through the Middle East using friendly countries such as Iran to finally reach India. This move, however, was not without considerable danger and risk of failure.

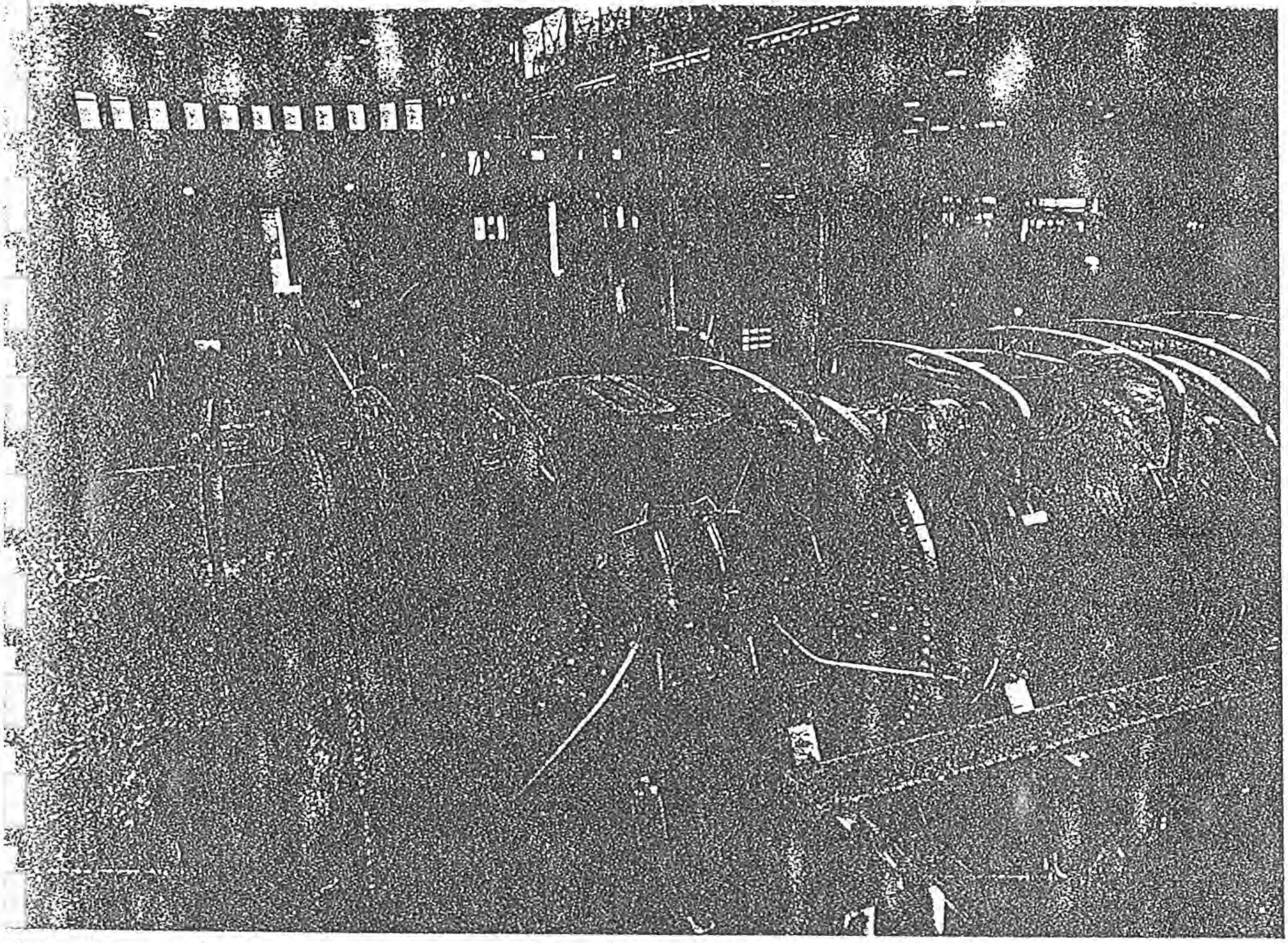
The air of uncertainty resulted in moves to find an alternative bearing and, while an answer was being found, drawings were prepared to substitute ordinary brass friction bearings on all axles should the roller races fail to arrive. As the situation worsened, Clyde was advised, on 4 June, to suspend manufacture of those details which were dependent on the roller races. The designs to meet the contingency were expedited and were finished during October.

In the Annual Report for the 1939/40 financial year, "substantial progress" was reported and "completion is expected before the close of the next financial year".

In the coming months, Clyde Engineering gradually assumed a defence role and commenced the manufacture of vehicles for the armed forces. The time spent on the manufacture of the locomotives was reduced as other priorities took precedence. While the boiler manufacture could proceed, the machine and fitting shops were gradually pressed into defence work "owing to the acute Pacific war situation".

The main frame, around which the 38 class was built, was cast in one piece. To the left of the cylinders with the valve chambers above, is the mounting for the air-compressor. An unusual inclusion on this patented American technology was the buffer beam but the manufacturers still included a hemispherical socket on its ends. These were used in America to secure poles used to push cars on adjacent tracks to minimise shunting movements. Their use was not condoned in NSW. *Photo: State Rail Archives*





'he boiler-mounted equipment has been installed on 3801 as it takes shape in Clyde Engineering's Workshop. The oval-shaped ndbox and its plumbing are in place while the Stones turbo-generator is positioned in front of the steam dome which is yet to ceive its cover. Steel ribs to support the streamlining have been riveted to their supports. *Photo: State Rail Archives*

Consequently, the next Annual Report was not as enthu-astic and, in their summary dated 30 June, 1941, the Commissioners lamented that "it had been expected that one of the ive new passenger type locomotives would have been deliv-ed during the financial year, but considerable delay has occurred because of difficulties met with by the contractor. Efforts have, however, been made to have the work expe-ted."

These efforts included the taking of some work into Rail-way shops, the detail fitting of the driving wheels being one em so diverted. Machining of parts was also undertaken in e Railway workshops to help speed the construction process. A liaison officer was appointed by the Department to eport problems as they occurred. Another ploy was to loan tting staff to Clyde to ensure that some staff, at least, would e working on the contract.

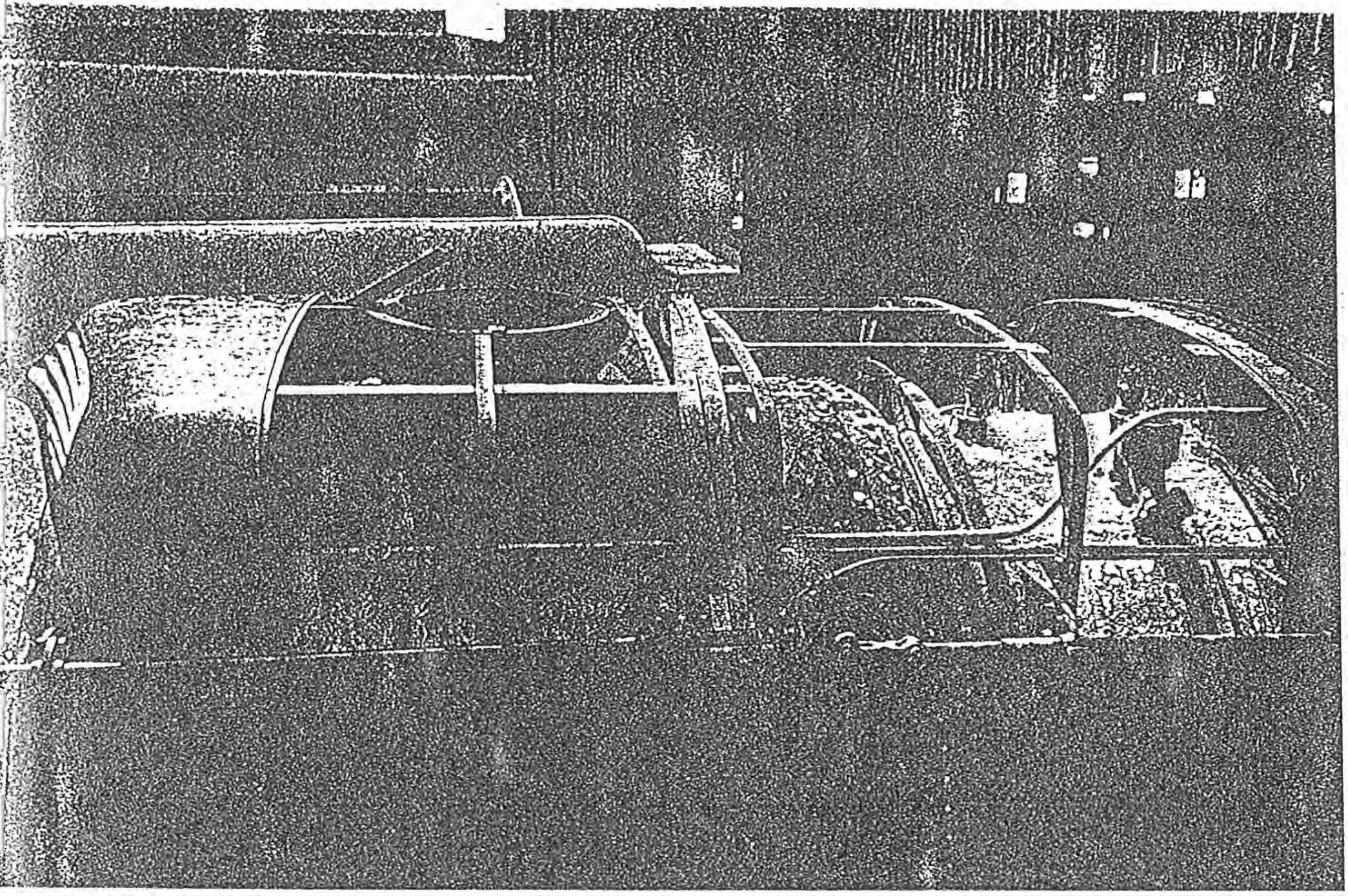
Relations between the Railways and their contractor were lways strained and considerable correspondence was ex-hanged on matters such as costing of tooling, the number of drawings supplied and rates of pay for the staff used. This last amed cost was a major problem as those men used on efence work were paid over award rates. Naturally, staff chose the higher paid job where possible and the 38 contract suffered as a consequence. Clyde suggested that it would help f the Railways paid similar rates for the locomotive work and this was agreed.

The following year more problems were evident and the report for the 1941/42 financial year bemoaned that "the necessity of giving priority to other goods under manufacture at the Contractor's Works again delayed execution of the order."

Included in the extra activities undertaken by Clyde and which delayed the construction of the 38 class were, of all things, some locomotives. The Department of Munitions, a Commonwealth body, had decided that Clyde's first priority lay in completing four Q class 4-8-2 locomotives for Tasmania while power station work came ahead of the 38 contract in their listing.

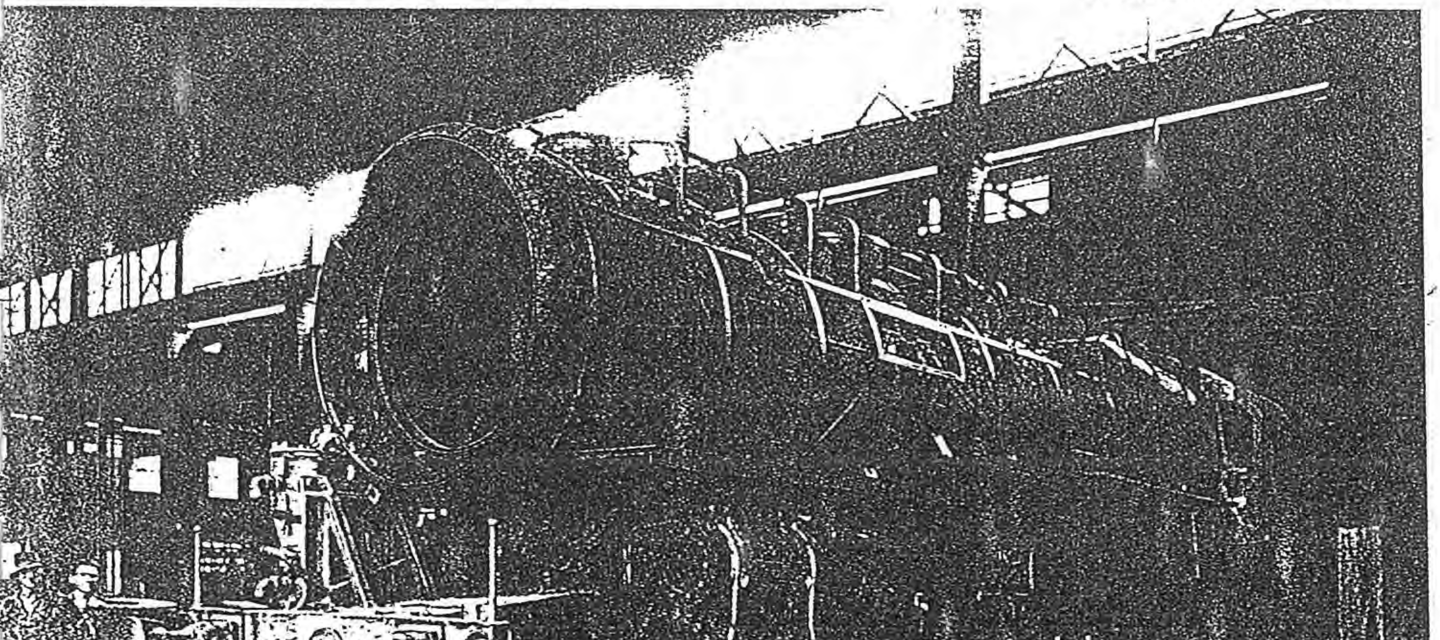
The fitting of some components, which had been manufactured over-seas, was also causing problems. Not the least of these were the aforementioned roller bearings of which there was still no knowledge of their whereabouts, let alone their expected delivery date. Finally, in August and September, 1941, the bearings for the axles in the leading and trailing bogies arrived but there was no sign of those for the main driving axles. Still, there was hope that the shipment was getting through and at the end of September, Clyde was advised to hold any further work on the substitute bearings.

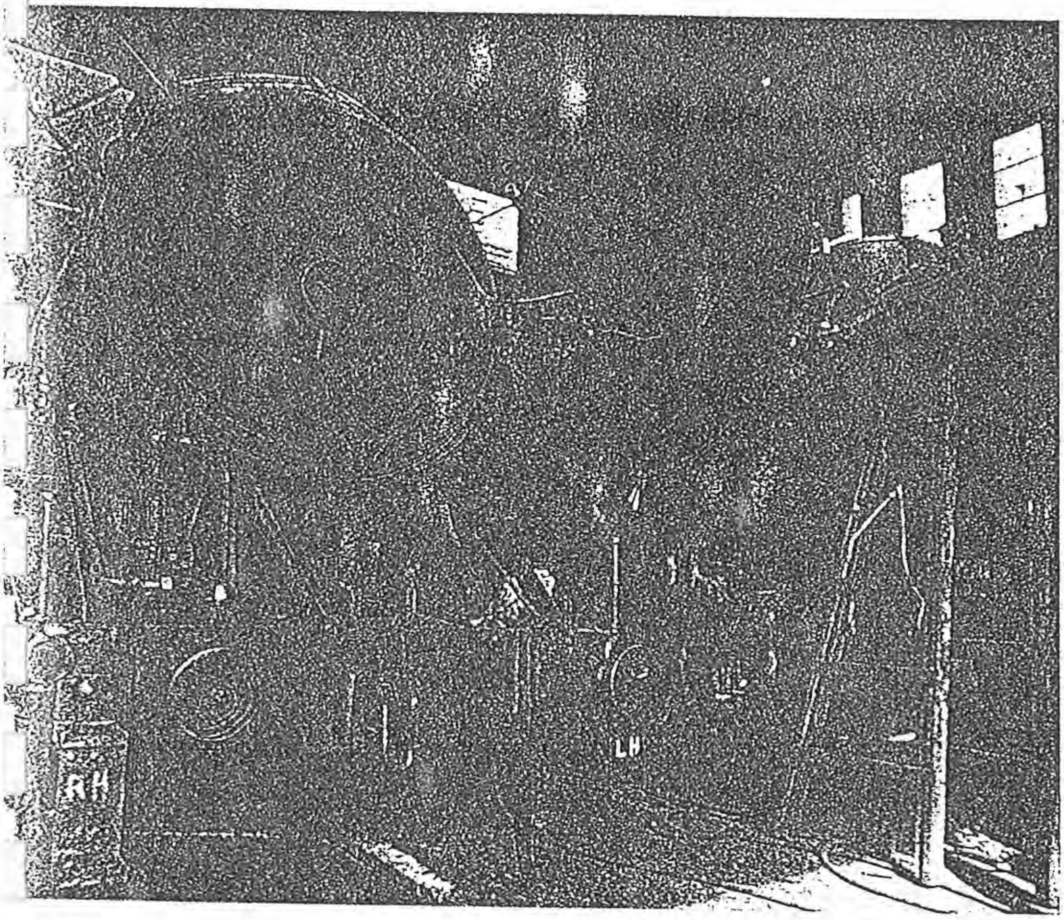
In 1941, with little progress to report, the situation reached crisis point and the future of the contract was under threat.



Details of the air-smoothing around the funnel (above). The grill at the front and the slope sheet behind were intended to lift smoke as the Pacific sped along. Work has come to a stop (lower photo) as the late arrival of the roller bearings has thwarted attempts to progress. Some of the valve gear rests on trestles unable to be mounted until the wheels are installed.

Photo: State Rail Archives





In late 1942, the bearings have been found and the wheels installed. Work can again proceed and staff employed in fitting the streamlining. The electrical conduit to the headlight has already been fixed in position and snakes into the nose-cone.
Photo: State Rail Archives

he pressure being applied by the Department resulted, on 3 March, 1941, in Clyde asking for a major variation in the scope of works to be carried out. More negotiations saw the order survive even though the total cost had escalated to over 124,000 ($248,000). Not all the problems lay at the contractor's end and more difficulties arose when the Department failed to meet some deadlines, particularly in the delivery of some components.

The boiler for the class leader was completed to the stage that it could be steam tested on 12 December, 1941. At least there was some cause for celebration.

The non-appearance of the many of the roller bearings continued to cause concern but on 8 February, 1942, S.K.F. advised that all bearings and their associated axleboxes had arrived in Melbourne having finally been shipped from Bombay. The word 'all' was examined and found to be an exaggeration. More instructions to Clyde followed outlining which axles were to receive the limited supply of roller bearings and which were to proceed with the substitute friction bearings. Even the axleboxes were the source of discontent and in April, the Department arranged to take over from S.K.F. all incomplete axleboxes and finish machine them at Eveleigh.

In July, more debate was recorded with the Department showing the contractor the extent to which it had assisted the project by machining various components. Clyde countered in August by advising that the supply rate was unsatisfactory!

Eventually, the problems started to disappear and even the long-lost roller races started to materialise.

By September, 1942, 3801 was 90% complete even though the last two engines of the contract were still only half finished.

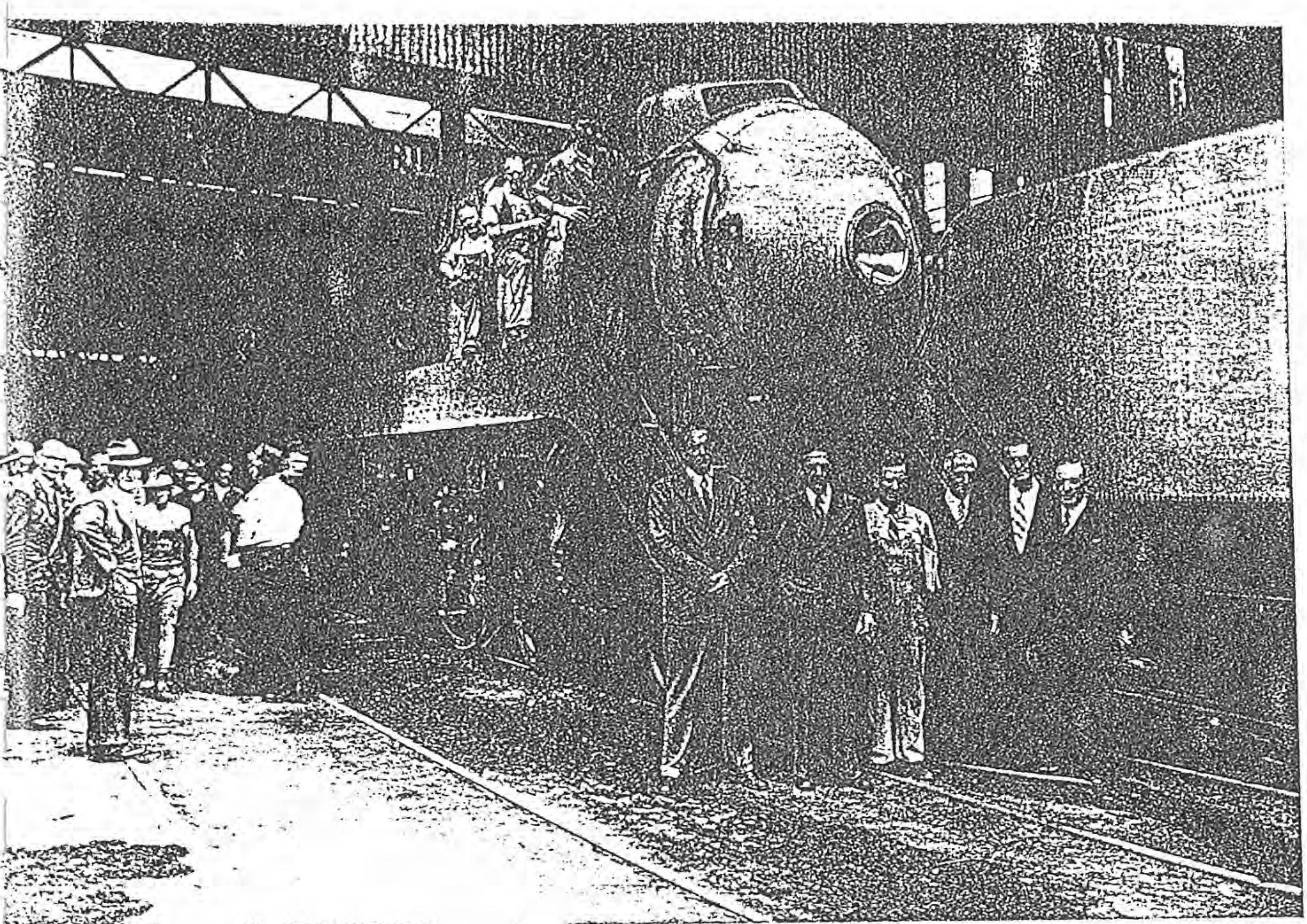
In December, 1942, the various lubricating oils and greases were sent to Granville. The first locomotive was nearly ready to roll.

Finally, on 19 January, 1943, 3801 was in steam and moving.

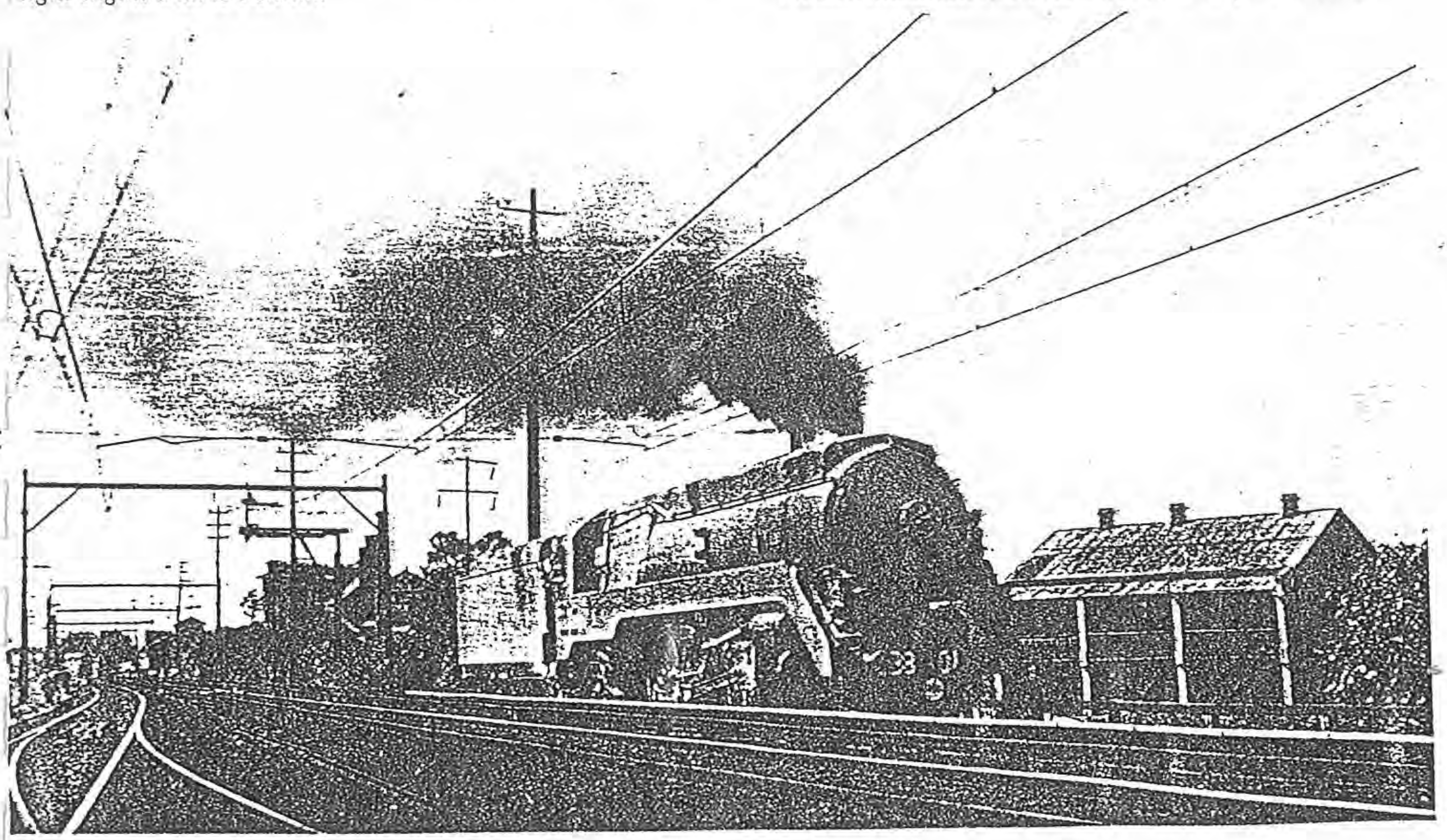
The next morning, the Sydney Morning Herald featured a photograph of the new engine ready to run its first trial, surrounded by Clyde employees. In the accompanying caption were the words "one of the most modern express locomotives in the world, designed and built at the Clyde Engineering workshops..." It was evident who had issued the press release! What was remarkable was that, in the stringencies of the war, film had been found to take the picture.

The official hand-over date was 22 January, 1943 and light engine (i.e. no train attached) trial runs followed. As befitted the prevailing wartime conditions, the impressive streamlined body was painted dull grey, a shade it was to carry until the situation too became brighter.

On 26 January, 3801 first earned money by hauling a 349 ton goods train from Enfield Yards to Thirroul and returned with another freight. This was the usual "running in" turn for steam locos and combined hill climbing, fast running and long braking stretches. Numerous curves tried out the running gear and, in all, provided a good test of the workmanship of



The end of 1942 found 3801 nearing completion and a visit was made by the Chief Mechanical Engineer, Harold Young (extreme right, above) and Commissioner Hartigan (third from right) to inspect progress. Officials from Clyde stood sternly with them for an official portrait. Several days later, 19 January 1943, the famous Pacific sets out (below) on its first journey in steam, a light engine trial to Penrith. *Photos: State Rail Archives and Noel Thorpe Collection*



the construction. After-trial adjustments were carried out at the end of the run. More trips hauling goods trains followed and the performance of the new engine was thoroughly checked.

It was to be over one month before 3801 hauled its first passenger train. Having hauled yet another freight to Goulburn, 3801 was requisitioned to work the up Southern Highlands Express. On the morning of 23 February, the big driving wheels gripped the rails to start this important business train into motion and the passenger career had begun. The next day, 24 February, the grey Pacific headed No.5 North Coast Day Passenger from Sydney to Broadmeadow. It returned that evening hauling No.10 Passenger. It is on record that, when heading up the torturous 1 in 40 of Cowan Bank, 3801 stalled apparently due to inexperience of the crew. Despite these problems, the 4-6-2 was able to restart its train and complete the journey.

Another notable first run, this time with the Newcastle Express, was made the next day.

By this time, confidence in the new engine was established and, as a prelude to the next test, the locomotive was run through Werrington at speed to test the operation of the staff exchanger. This test used the "standard" exchanger, installed on this fast section for such testing.

Having passed this trial, 3801 was rostered to work the train for which it had been designed, the Melbourne Limited Express. This train was hauled the 400 miles to Albury and return, again proving its suitability and allowing any adjustments to be identified and made.

Training of crews followed and, when sufficient men were available, 3801 was issued to general service.

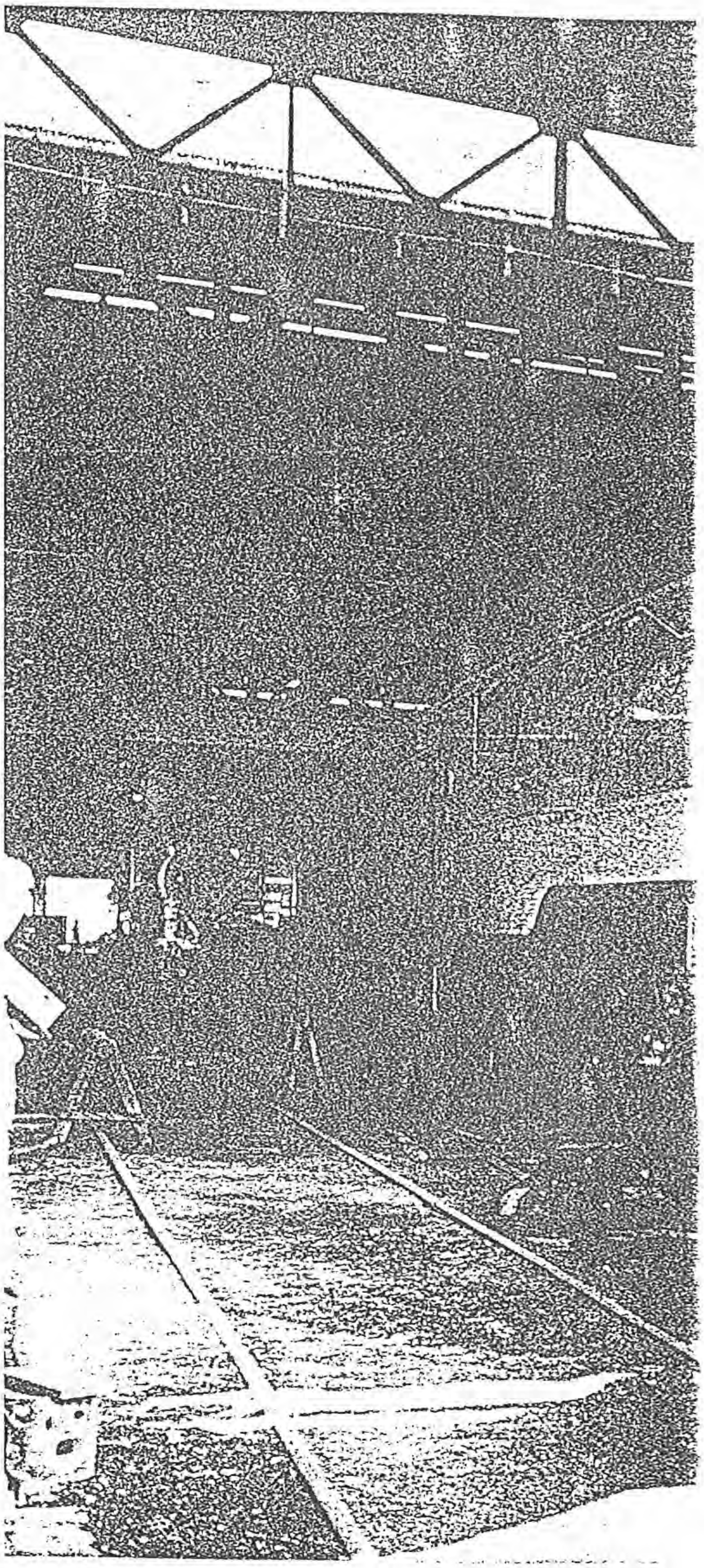
Things were not proceeding as well for its sister streamliners and their first journeys would not take place until 8 April for 3802, 9 September for 3803 and 10 February, 1944 for 3804.

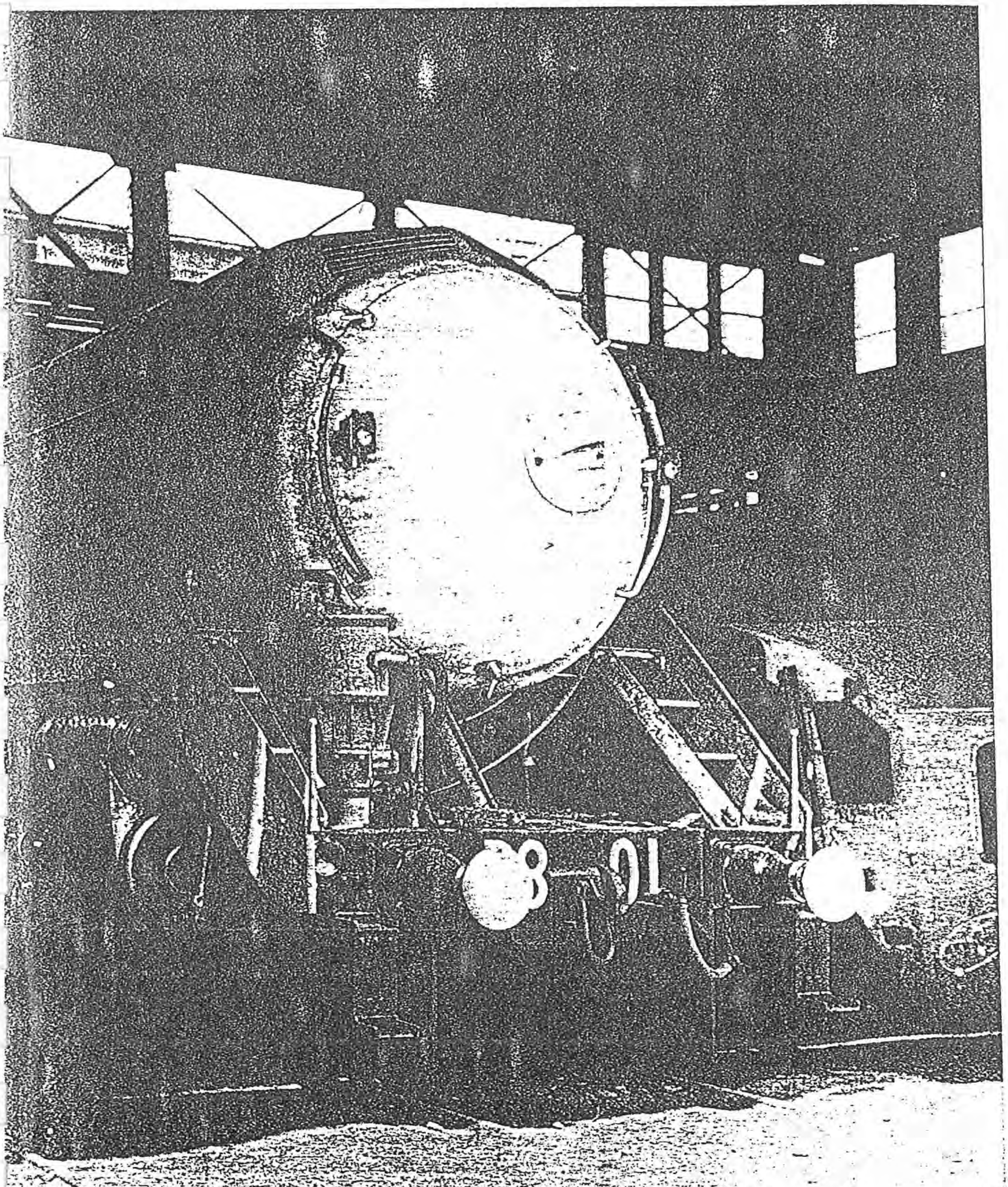
Even with their new show-piece in service, the Commissioners could not hide the frustrations of five years of problems and postponements. Their last report on the subject described the delay as "disappointing" and their final sentence summed up their feelings. "Only slow progress was being made on the fifth engine at the end of the year, owing, it is understood, to the diversion of staff, under War Cabinet direction, to the construction of Garratt locomotives." What added salt to the wound was that not only were the Garratts for Queensland, but that they were already poorly regarded by their recipient crews.

A problem in the frame further delayed 3805 and it did not see service until 2 March, 1945.

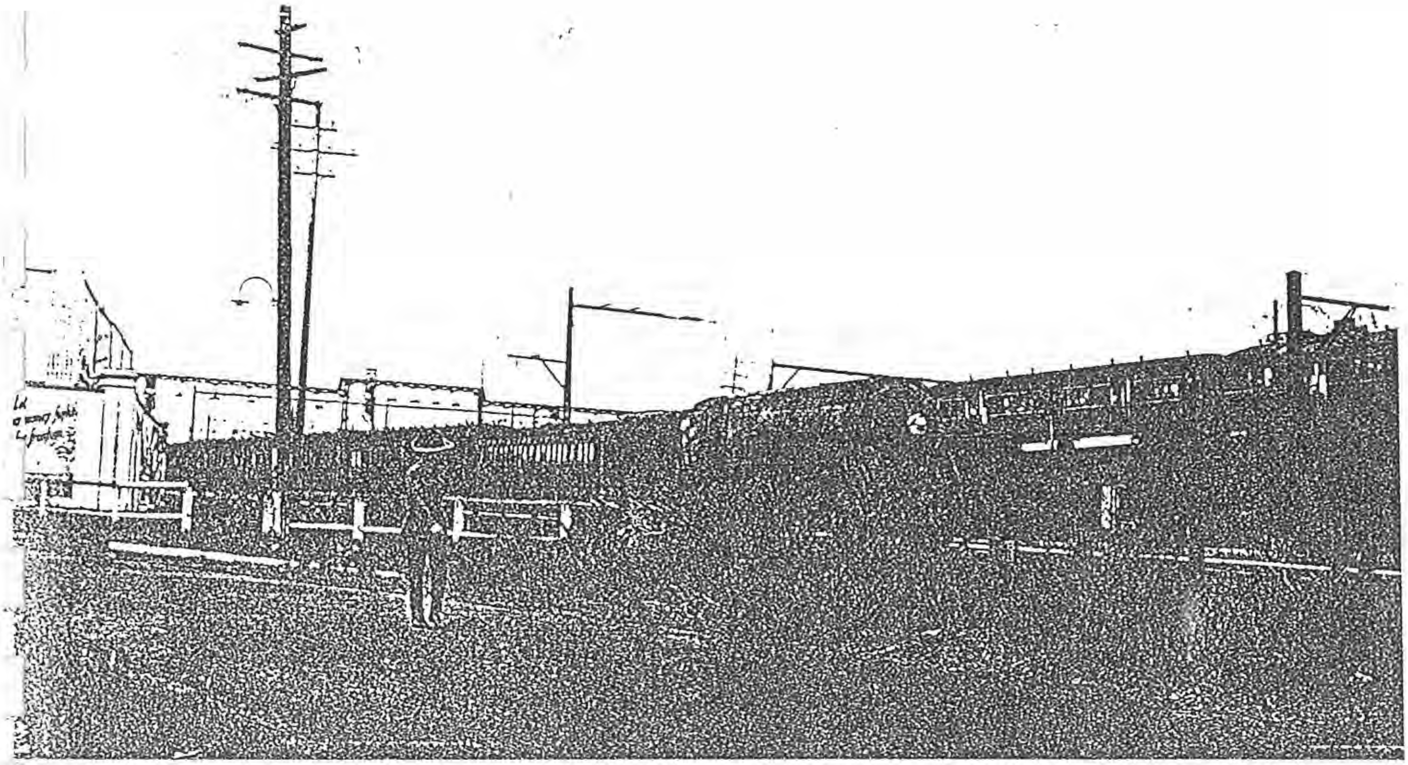
In the final analysis, the five locos had cost £215,046 ($430,092), more than twice the original estimate.

Despite all the traumas, in spite of all the difficulties, what was destined to become arguably Australia's most famous steam locomotive was alive and in steam.

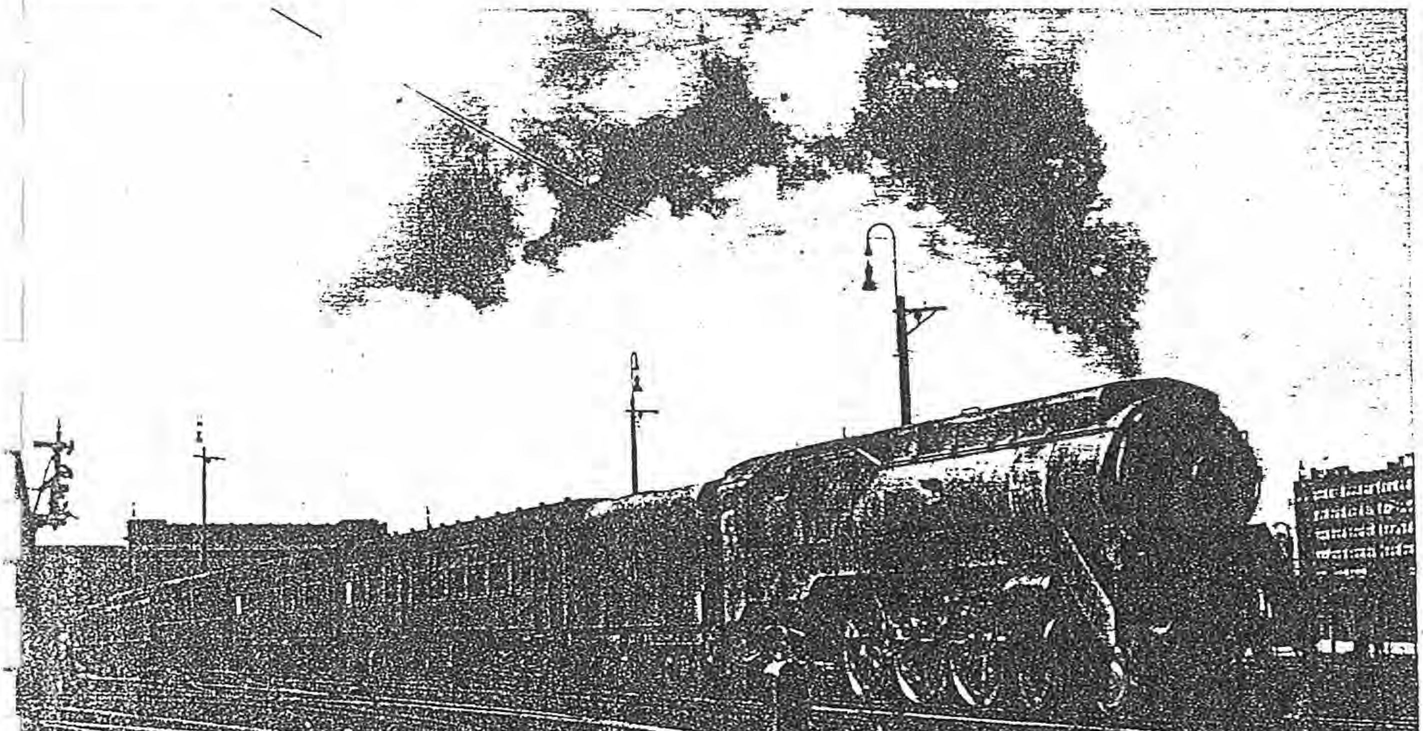


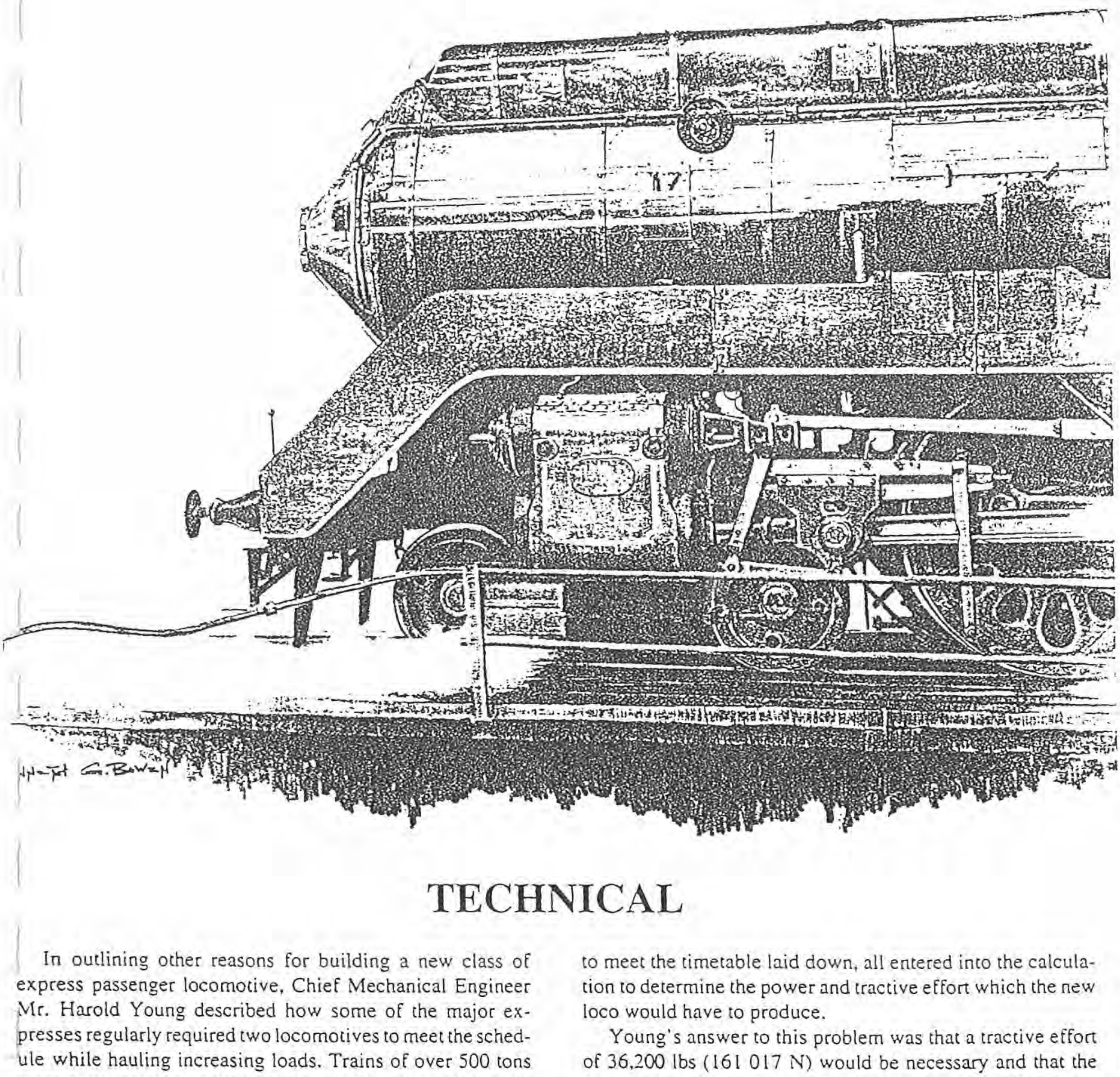


After many months of frustration and innumerable arguments, the future pride of the express passenger fleet stands ready to make its entrance, albeit in grey paint, an economy of the prevailing war-time conditions. Only the red of the buffer beam brightens the appearance which was soon to gain 3801 the nickname of "The Grey Nurse". *Photo: State Rail Archives*



ıe streets of Strathfield (above) have little traffic during the dark days of World War II save for a khaki-clad soldier home on ..ave. From behind, comes the grey form of 3801 as it departs Strathfield with a mail train under the watchful gaze of the guard f the suburban electric as it rolls down from the fly-over. Sydney Yard is the setting for the lower photo as the grey Pacific sets ıt on another express run. Photos: Noel Thorpe Collection





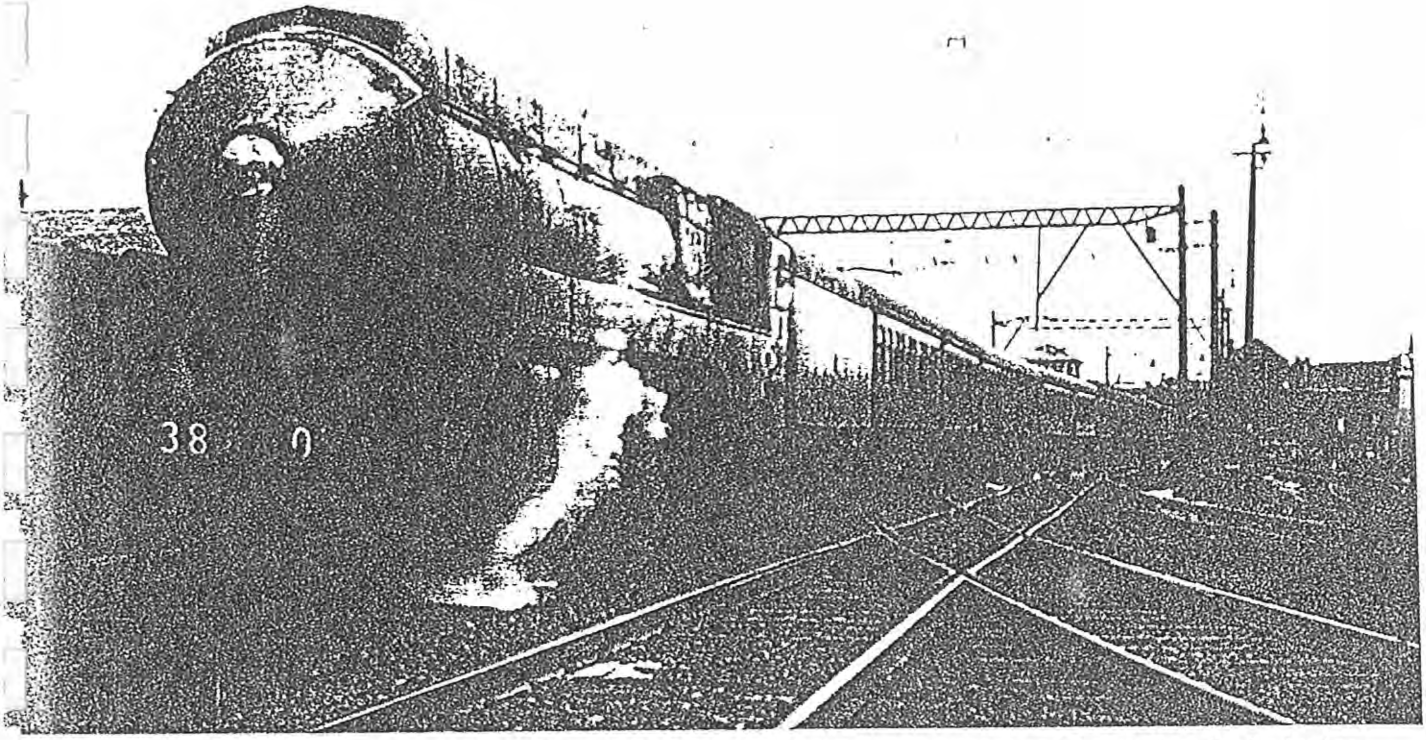
TECHNICAL

In outlining other reasons for building a new class of express passenger locomotive, Chief Mechanical Engineer Mr. Harold Young described how some of the major expresses regularly required two locomotives to meet the schedule while hauling increasing loads. Trains of over 500 tons were now common and the Melbourne Expresses frequently reached 550 tons and on the 1 in 40 grades south of Goulburn, two 36 class were used to maintain the exacting timetable. This was a waste of engine power and it was argued that a locomotive could be designed to handle many of the regular trains without the use of assistant engines.

It was this task which formed the basis of the design criteria. An analysis of the weight of a typical train, the grades up which it had to be hauled together with the speed required to meet the timetable laid down, all entered into the calculation to determine the power and tractive effort which the new loco would have to produce.

Young's answer to this problem was that a tractive effort of 36,200 lbs (161 017 N) would be necessary and that the horsepower developed by the cylinders should be 2036. From these fundamentals, the dimensions of the locomotive could be determined.

With a wealth of experience on which to base its design, the team of engineers based in Transport House, set out to combine the best of all worlds in their new locomotive. New South Wales had been well served by British technology over many years and, in several excursions into American practices, much had been learnt and valuable experience gained.



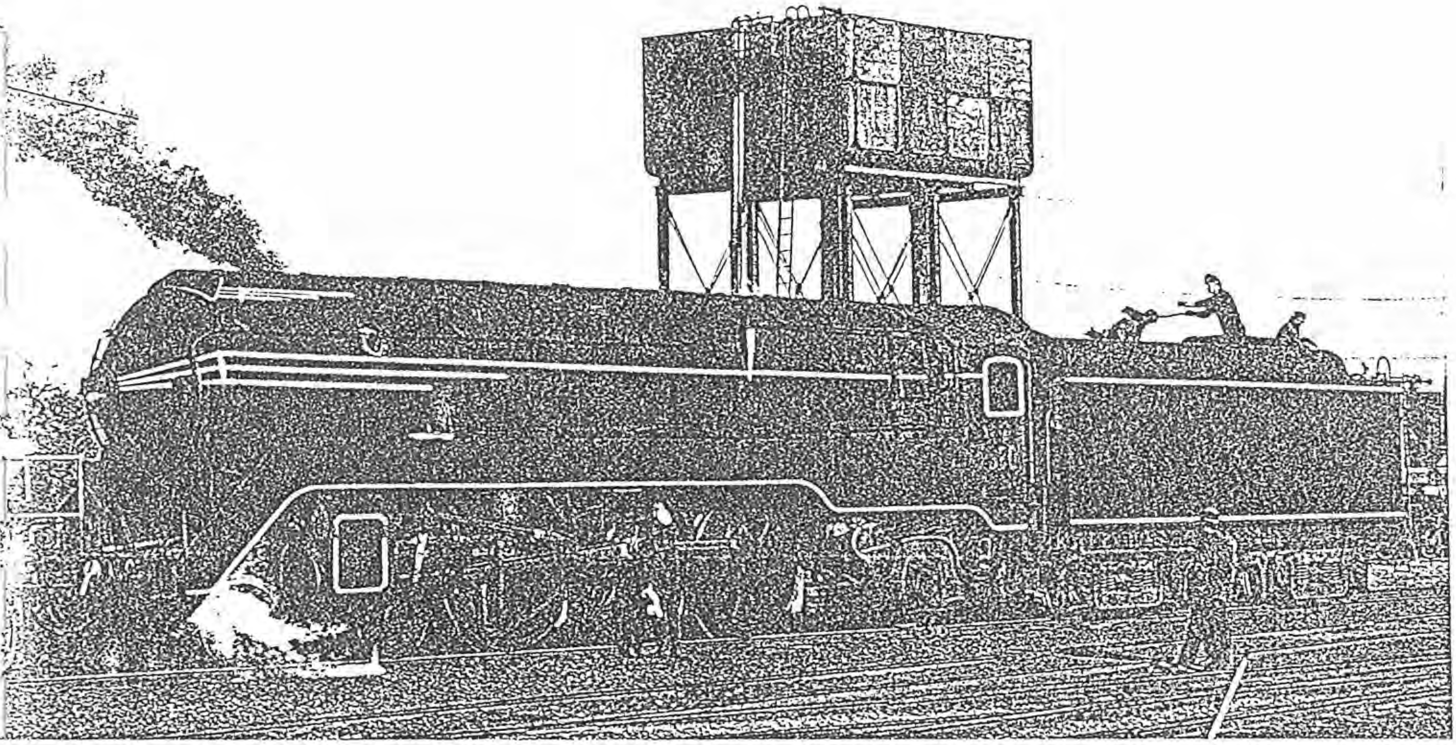
38 class were designed with the important Melbourne Expresses in mind. A wartime scene as the grey class-leader brakes ɿeavy load of timber cars, loaded with interstate travellers, for a gentle approach to Sydney Station.
Photo: State Rail Archives

Young's team set out to produce a design which embodied ıe best of previous engines and the features of which they d learnt in their design philosophy. In keeping with modern ıerican practice, a cast steel engine frame provided the ıis for their creation. This was now universal on all steam signs from across the Pacific and had been used in New uth Wales since 1929 under the 57 class goods locomoes. Repairs to those frames had been negligible and mainenance costs had been significantly reduced. As the ommonwealth Steel Company held the World patent, all ch frames would have to be manufactured in America and ıported. It was calculated that had a plate frame, the stanrd on passenger power up 'til now, been used, an additional 5 tons in weight would have been added to the engine. The ame was an ingenious casting and an outstanding piece of ngineering. Not only did it form the structure on which the oiler and smokebox were mounted and in which the wheel earings and axleboxes were supported, it also came complete with the buffer beam at the front and the trailing awgear pocket under the cab. Cast integral with the frame ere the two cylinders that powered the mighty pistons and e valve chambers or chests which distributed the steam to em. Many brackets and supports were part of the casting nd components such as spring beams, air compressor and alve motion were mounted on suitable inclusions cast on the casting. Perhaps the most remarkable of all these appurteances were the main air reservoirs which were cast integral ith the frame.

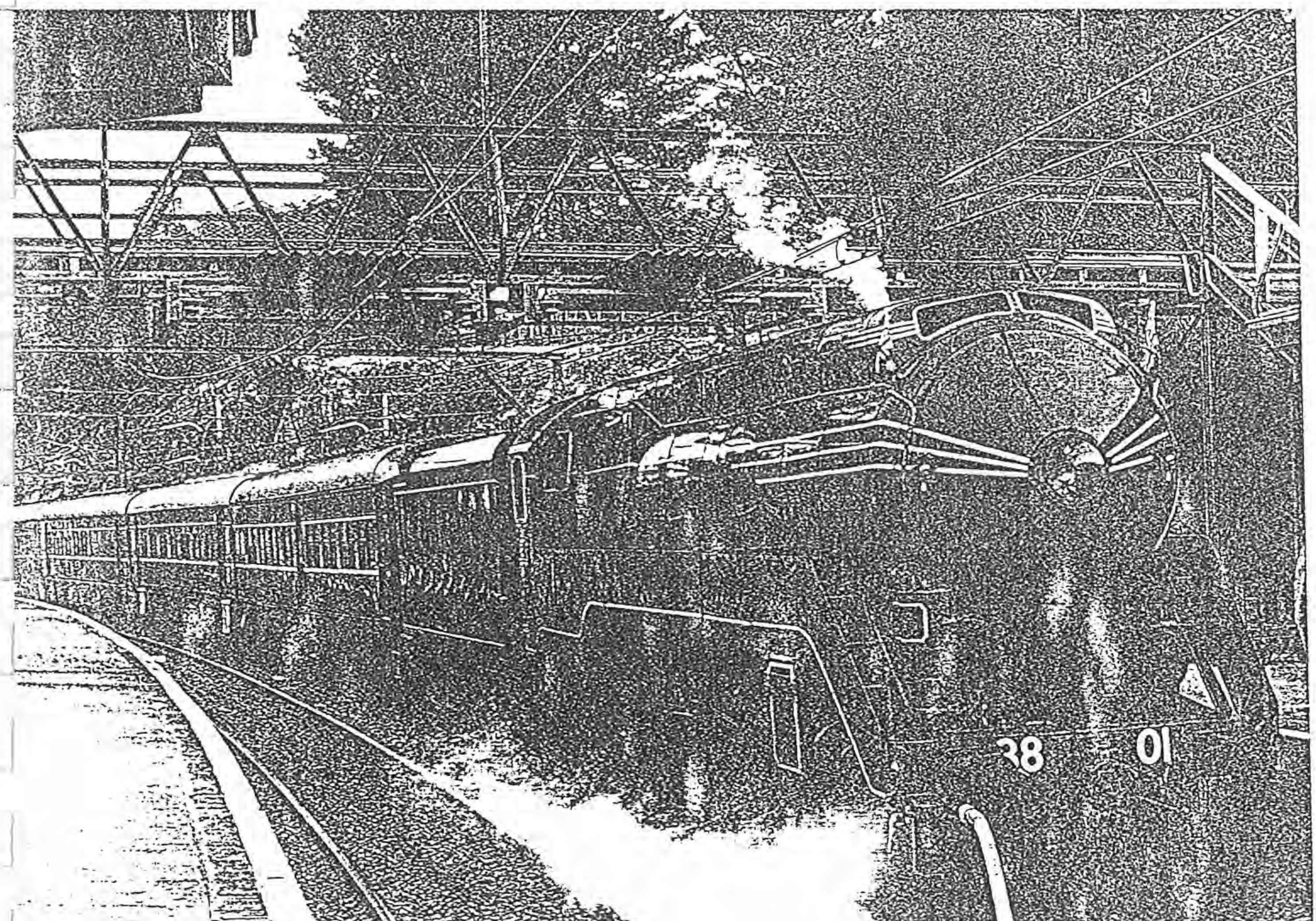
In further justifying the choice of a cast frame, the CME ointed out that the steel used was suitable for repair by velding thus making provision for any future mishap.

A major decision was required in deciding the wheel and axle assemblies to be used. From the calculations which outlined the tractive effort required and from the weight permitted on any axle, the number of driving wheels were determined - six. It was New South Wales, if not world practice to use a four wheel leading truck to "steer" the locomotive around curves and the design was so arranged. The last factor to be considered concerned the balance of the locomotive, the total weight, the number of axles to carry this weight and the size of the firebox required. From these thoughts, it was decided that a two-wheel trailing truck would be required to meet the design criteria. Consequently, a 4-6-2 or Pacific wheel arrangement was specified, the first such configuration in New South Wales. In 1930, the Timken Roller Bearing Company suggested that their products could be used to improve the efficiency of steam locomotives. Rejection of their ideas by the conservatives of the time resulted in the company buying their own locomotive to prove their point. When three Pennsylvania office girls were able to pull and move their locomotive, the conversions came thick and fast and the results in service convinced Young that his new creation should be so fitted. The cast frame was designed and ordered to suit.

The driving wheels were required to speed the trains at the then maximum road speed of 70 mph (112 kph) and following the accepted "rule of thumb", one inch of diameter for each mile per hour, 5'9" (1 752 mm) wheels were specified. It is tempting to suggest that Young considered larger driving wheels (American railroads frequently used 80" (2 032 mm) wheels) but it was realised that this would have required a longer boiler to accommodate them. This would have altered



Coal and water requirements were vital factors in the design of the 38 class. In recent times, when steam facilities have been removed, these same factors form a major problem for operators such as 3801 Limited in meeting the needs of their famous locomotive. During the servicing time at Goulburn, (top) Company fitter Garry Ballhause oils the side rods, while other members are in the tender to shovel the remaining coal forward within reach for the return journey. A trip west and, at Mt Victoria (below) 3801 has its water supply replenished by connecting a hose to the pipe which is fitted to the front buffer beam to allow water to be pumped from water gins to any locomotive coupled in front. Photos: Garry Kahler



ıe gas heat transfer calculations, made the wheelbase longer d even made the locomotive too long for the turntables in .. areas where it was intended to operate. An increase in ylinder diameter would also have been necessary thus mak- g the engine too wide. The Boxpok cast design was adopted the big wheels as these were proving maintenance free on American railroads. Heavy wheels such as these can be nishing on the track if not balanced. A special dynamic lancing machine was used to add weight, generally lead, nto various pockets provided in the wheel to ensure as smooth a passage in service as possible. When all the forces hich are imposed on a driving wheel are analysed, it is not ossible to eliminate them all despite means of "cross balancing" to allow driving wheels on the same axle to compensate r the other. If the wishes of the permanent way engineers ad been completely met, the forces within the locomotive would have been excessive and vice-versa. A compromise had to be reached and was extended to include operation up 90 mph (145 kph). The final result was an exceptionally smooth running locomotive which, on some future occasions, exceeded its designed speed limit without ill effect. At the ame time as the calculations for the Pacific were taking lace, the opportunity was taken to investigate improvements to the 36 class 4-6-0s.

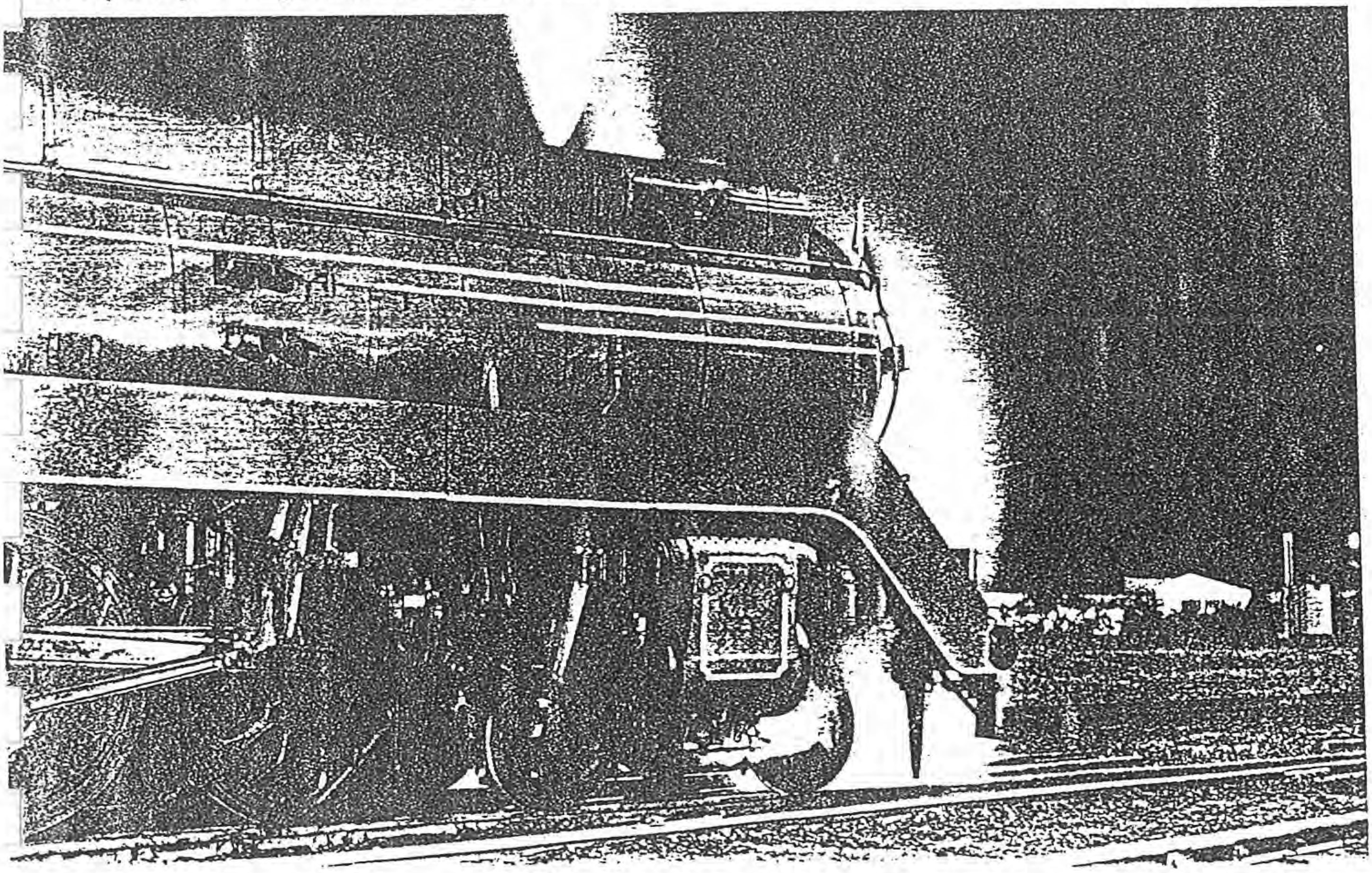
For the leading truck, 36" (914 mm) inside journal vheelsets were specified for use in the one-piece cast frame, equalised by beams and springs. A standard design "Delta" two-wheel trailing truck was ordered with 42" (1 066 mm) outside bearing wheels. All wheels in these bogies were balanced for 90 mph running and their tyres were secured with Gibson rings.

To provide the necessary tractive effort from such wheels, the team decided on cylinders 21½" (546 mm) diameter, a dimension desirable to stay within the NSWGR loading gauge. A piston stroke of 26" (660 mm) was almost universal on NSW passenger power and was again specified. Air operated drain cocks were fitted at each end under the cylinders to remove condensate. Twin Cardew pressure relief valves were fitted to each cylinder for protection from unforeseen pressure build-up.

Walschaerts valve gear was specified as it had given satisfactory performance on the 36 class and was a preferred arrangement on most English locomotives. A large reversing link was specified to allow fine adjustment of the travel of the 12" (305 mm) diameter valves which controlled the admission and exhaust steam events to the cylinders. A power assisted reversing mechanism, described by Young as "an ingenious device", was used to further improve the control and adjustment of the valves. It was mounted on the footplate ahead of the firebox on the driver's side.

In previous locomotives, the connecting rod, which transmitted the forces from the pistons to the main crank pin had gunmetal bearings in the little, crosshead end and big or crankpin end. While these operated reasonably well, Young's team saw an improvement to minimise the forces which movement of the locomotive in service placed on the various parts. For the 38 class, a six inch diameter spherical gunmetal bush was provided between the split gunmetal bush in the

Night at Taree Loco and the big Boxpok cast driving wheels and the Walschaerts valve gear are at rest as the Bicentennial train pauses for the night while on its way to Brisbane in 1988. *Photo: Ron Preston*



ie end. This novel feature was to be lubricated every 400 'es (650 km).

he most time consuming component for the team to gn was the boiler as the horsepower developed by the :omotive rested squarely on the ability of this pressure el to generate the steam necessary. Fundamental to this city was the ability to burn sufficient suitable coal on the ate to produce the heat to boil the water to generate the m to power the cylinders to turn the wheels and haul the . Another factor to be considered was the type of coal to used. Here was a decision which would determine the ure performance of the class for without the proper fuel, steam would not be produced. When all coals available e analysed, it was found that Abermain Colliery between aitland and Cessnock produced a coal that met all require- nts and was perhaps the best locomotive fuel available. en all the calculations were done, a grate area of 47 square et (4.32 sq m) was considered right. This conclusion pro- ced much discussion for the area was only marginally ow the generally accepted limit for hand firing. Automatic kers were available but had the disadvantage of being asteful on fuel. The decision was taken to stay with hand ng, much to the disappointment of generations of firemen ollow.

The next consideration in the design was the size of the ebox. The heating surface area was set at 225 sq ft .66 sq m) with the expectation that 55 pounds of water ould be turned into steam from each square foot of surface ch hour. A Belpaire firebox which featured a box like ipe, was chosen. In some older locomotives, a round top ebox had been used and, while cheaper to manufacture, had n inferior heat transfer capability to the square cornered lpaire. Five 3" diameter arch tubes to circulate the water ound the fire box area assisted this capability and also acted s a support for a brick arch to improve the combustion of the al in the firebox.

The next factor to be designed in the generation of steam s the number and size of the tubes which carried the hot asses from the fire through the water space of the boiler.

As a superheater was to be fitted, 36 tubes with a diameter 5¼" (139 mm) were provided together with 142 smaller ubes of 2¼" (57.1 mm). All tubes had a length of 17'9" 410 mm). The superheater elements were installed in the rger tubes and contributed 755 sq ft (69.46 sq m) of heating surface. The total area of all the tubes was 2361.51 sq ft 217.25 sq m).

In all, the ability of these surfaces to generate steam was asoned as producing sufficient steam to allow the cylinders to produce 2021 horse power. The team was satisfied with is result as it was argued that "the rate of coal consumption n be increased when necessary to give a higher horse power... but is uneconomical in fuel consumption."

Economy was always a consideration and Young pointed ut that the fitting of a superheater would save some 20 to 25 ercent in the cost of fuel.

A tapered boiler barrel was to be used and in making this ecision, the designers set themselves a problem to solve. The front of the outer firebox was sloped and a special transition piece had to be designed to join the barrel to the firebox. A one piece pressing was ordered and the arrangement was described as "interesting and original". The grate on which the fire burned was made in sections which could be rocked from the cab to dislodge ash or, at the end of a trip, to tip the fire into the ash pan beneath. This container held the waste from the fire and could be emptied by a hand operated door which was operated from ground level. A water flusher was operated from the cab as were the damper doors to slow the rate of combustion by limiting the air supply.

As designed, the boiler produced steam at 245 pounds per square inch pressure (1 688 kPa), the highest pressure used on a locomotive in Australia. Three 3½" diameter Ashton Muffled Pop Safety Valves, type F.C.10 were fitted to release excess pressure and a safety factor of five was used in all calculations. Four plugs filled with tin were provided in the crown sheet of the firebox to protect the boiler from damage if the water level dropped too low.

Three "blow-down" cocks were fitted to allow the salts and sludge which collect near the bottom of the water space to be ejected from the boiler.

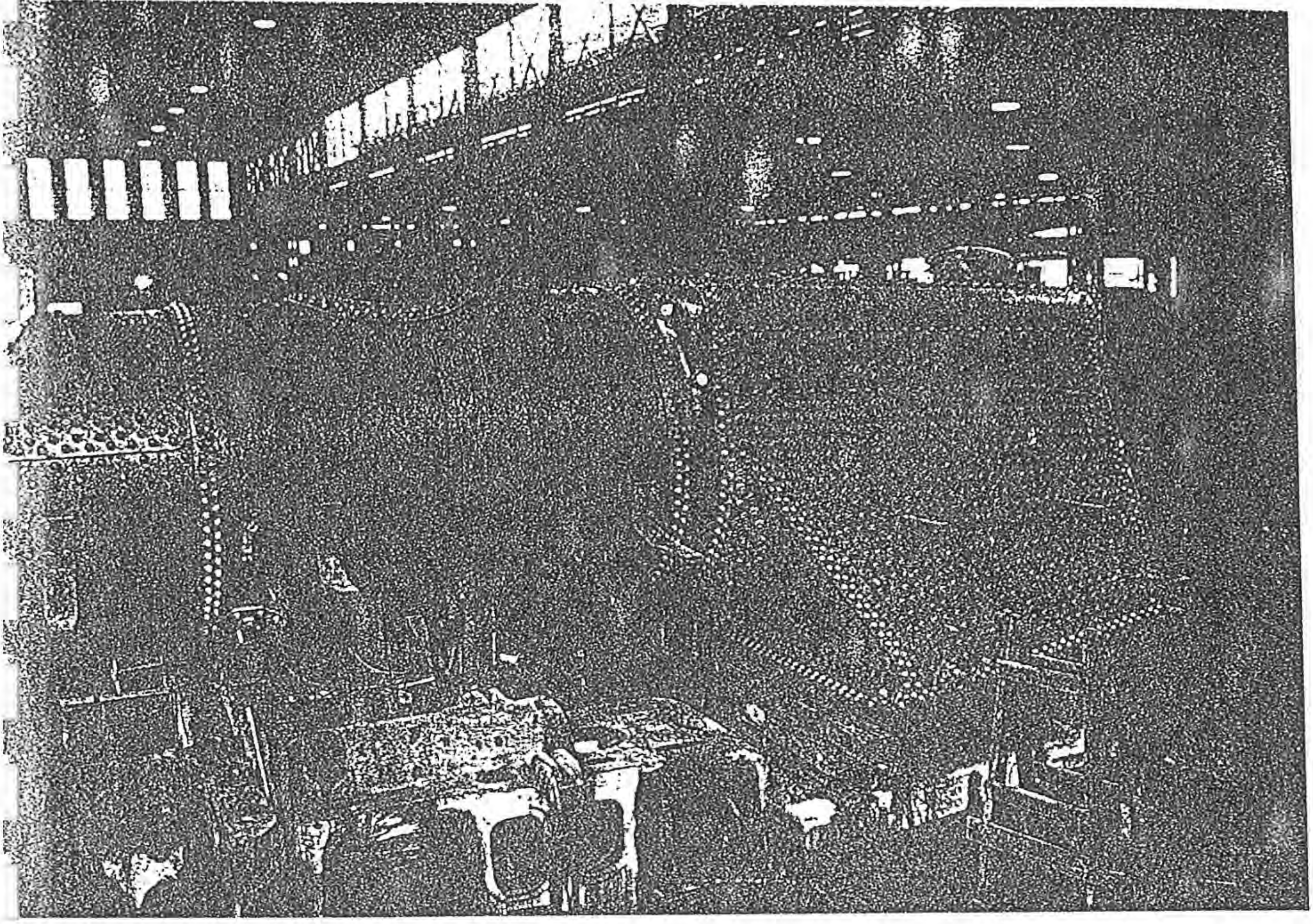
The steam generated is collected by a tangential dryer in a "dome" mounted centrally on top of the boiler barrel. This allows the steam to be taken to the regulator in an eight inch diameter steel pipe as free of water as is possible.

At the front of the boiler, the smokebox contained a number of features. The header in which the steam from the boiler was collected, also contained the regulator which controlled the steam first to the superheater and then to the cylinders. The steam temperature to the cylinders can be in the order of 650 degrees Fahrenheit. The valves in this control were operated by a long rod which reached from the driver's position in the cab. It is also serves to provide a hand rail for staff passing along the footplate and consequently was fitted outside the streamlining which envelops the boiler. A fulcrum on its centre was included so that the regulator was not affected by expansion of the boiler.

A vital role for the smokebox is to produce a draft to draw air through the fire and the gasses through the tubes. Once in the smokebox, these gasses must pass through a spark arrester to filter out any cinders which could start a fire in surrounding vegetation. The draft is created by placing the cylinder exhaust steam nozzle, the blast pipe, under and concentric with the chimney which had a taper of 1 in 15 in its upper sections. This taper creates a venturi effect resulting in the flow of gasses through the boiler. The chimney protruded through the barrel and was designed to finish flush with the streamlined shell. Another fitting around the nozzle was the blower ring which could be operated from the cab to direct a stream of steam up the chimney to create a small draft while the locomotive was standing or drifting in traffic. Boiler pressure was improved by its use.

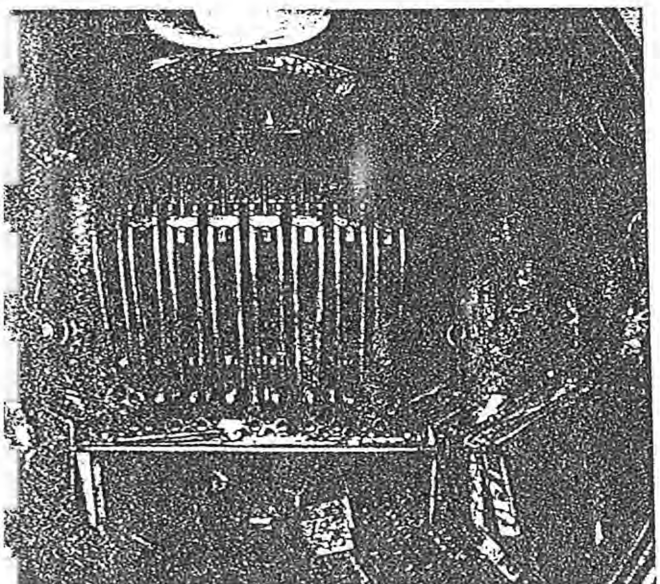
The mesh in the spark arrester was ¼" (6.5 mm), a dimension deemed suitable to retain cinders likely to start grass or scrub fires if they landed on surrounding country.

A damper was provided to close off the draft while the



‑ most complicated calculations for the team creating the :lass involved the design of the boiler. The numerous stays ›ı the side of the huge pressure vessel (above) as it rests ·mporarily in the frame at Clyde Engineering. The air res- oirs, which are cast into the frame, are immediately below dome section. In the smokebox, (below) the superheater ıbes are in position and the main steam pipes curve around side walls from the header to the cylinders.

Photos: State Rail Archives



locomotive was drifting and not using steam. At this time, the pilot valve admitted sufficient steam so that a vacuum was not formed in the cylinders. The driver was required to ensure that this control was operated correctly as a vacuum could draw abrasive ash and cinders into the valves and destroy their sealing surfaces. A gauge was provided in the cab to display the pressure in the main steam pipe to the valves so that the regulator could be adjusted accordingly.

The door on the front of the smokebox was vital to the correct steaming properties of the boiler. Not only did it help retain the heat, it also had to be air tight so that the vacuum formed by the blast was not destroyed. A circular flanged plate five feet (1 524 mm) in diameter was devised as the answer to this problem and made its face with the front of the smokebox in a V-grooved ring. A dart shaped locking bar with an arrow shaped head inside and a screw thread on the other end, was used as on most New South Wales locomotives to hold the door shut. Located in the centre of the door, it was locked by first turning the dart horizontal thus allowing the head to pass through a slot in a bar across the centre of the smokebox opening. A handle on the outside of the door was then turned through 90 degrees to initially lock the door after which a round wheel shaped "nut" was turned to tighten and pull the door tight. The fitting of the streamlined casing to 3801 and its four sisters hides this door when in service. It is prominent on the unstreamlined version, 3806 onwards.

On the top of the smokebox immediately above the regulator, a rectangular opening was provided to gain access to the six valves which controlled the flow of steam to the

'linders. The first of these was an "easing valve" to balance pressure in the regulator with that in the superheater ler thus giving a smooth control. Next to open was the lot valve which admitted only sufficient steam to maintain ositive pressure in the cylinders. Further opening of the ottle" opened, in turn, valves 1, 3, 2 and 4 again balancing ssure in the head while steadily increasing the volume of eam to the cylinders.

Other fittings vital to the boiler were the two 11mm live m injectors which supplied water to the boiler. Each could eliver 3,400 gallons per hour and, while it was the fireman's fitting that was usually used, it was not unusual to find injectors operating when the mighty locomotive was owering a major express up a grade and the engine was being hed to the limit to maintain the timetable.

Water flowed from the injectors through copper pipes ards the front, top of the boiler barrel delivering the cold luid to an area where it created less thermal stress in the steel to variations and fluctuations in temperature. To stop am and boiler water flowing back after the injector was urned off, non-return or clack valves were provided where pipe entered the boiler barrel. Again, the streamlined ing hides these features on the first five locos.

At first it appears strange that a locomotive delivered in he midst of a World War should come with the luxury of eamlining as it was desirable to conserve resources at this e. However, the five 38 class had been ordered under peace conditions and, at that time, the attractions of stream- e were alive and well throughout the railway world. In nerica, many new passenger locomotives were being or- dered with a stylised outer skin to not only improve fuel onomies but also for its customer appeal in a competitive ssenger market.

A style which caught the eye as well as having the practical attributes was that used on the New York, New Haven and rtford's I-5 class 4-6-4 locos built by Baldwin in 1937. The llet-like nose with upper shroud gave a purposeful look together with the streamlining that was proving a marketing inner. The American engine had 80" drivers and conse- ently a narrow valance along the footplate while a deep shroud covered the front below the smokebox and flared into a wide pilot or "cowcatcher". This made access to fittings ounted ahead of the cylinders difficult. When added to the cessity for a buffer beam on the New South Wales engines, a decision to shroud only the boiler was taken. A deep valance as provided along the footplate and this styling was swept own ahead of the cylinders to add elegance and symmetry. Two sweeping steps ahead of and below the cab carried the ower line of the valance to tender tank level to maintain a nified look. The cab fitted in with the outer dimension and as tapered on its leading face to lessen air flow resistance.

Mounted in the upper shroud ahead of the dome was the andbox, positioned to facilitate the flow of sand ahead of the oupled wheels.

One concession to positioning a fitting outside the shroud as the mounting of the whistle. The standard NSWGR ive-chime whistle was used and was placed at the front of the boiler to allow its sound unrestricted course to objects ahead. It was located on the fireman's side since that crew member had the lesser chance of being in his seat and thus have his hearing effected by the noise. In deference to the distance from the cab, the valve which admitted steam to the chamber was operated by compressed air which, in turn, was controlled by valves operated by the crew.

A cross-compound air compressor was chosen to supply the compressed air required for air brakes and other controls. Extensive testing of the compressor was carried out on a 50 class 2-8-0 goods engine to prove the reliability and cost effectiveness of the type. It was mounted on a bracket cast into the frame ahead of the cylinders and under the smokebox on the fireman's side.

Two lubricators were mounted on the footplate alongside the boiler on the driver's side. Operated by linkages which were connected to the valve gear, they supplied lubricating oil to various moving parts. The Nathan mechanical lubricator with six feeds and fed with steam, supplied atomised oil into the steam pipes, valve chambers, cylinders and air compressor at all times the locomotive was in motion. An additional six-feed lubricator fed oil to all of the axlebox guides and to the slide bars.

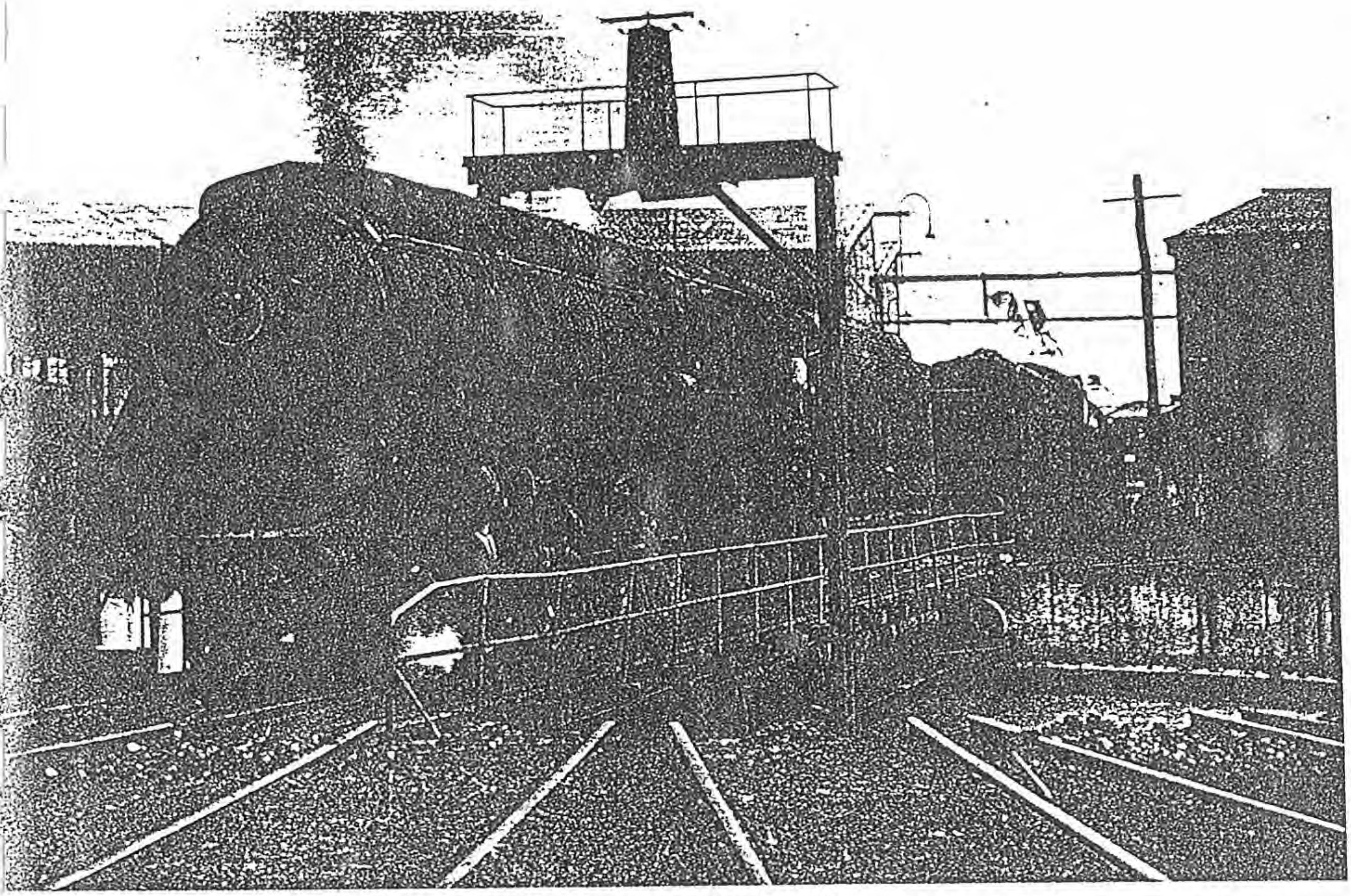
A commodious cab provided for the crew who were to operate the 38. Care was taken in its design to ensure that good visibility and two padded seats, a luxury on NSW steam locos, provided for the comfort of the crew. For the driver, the regulator, reversing wheel, cylinder drain cocks, sand and whistle controls were within easy reach. A two-handle air Westinghouse A6-P brake stand was to his right with an independent valve to control the brakes on the locomotive only and a larger valve for the automatic or train brakes. The braking system used A6-ET type equipment. Two small wheels operated valves which controlled the steam supply to the air compressor and driver's side injector.

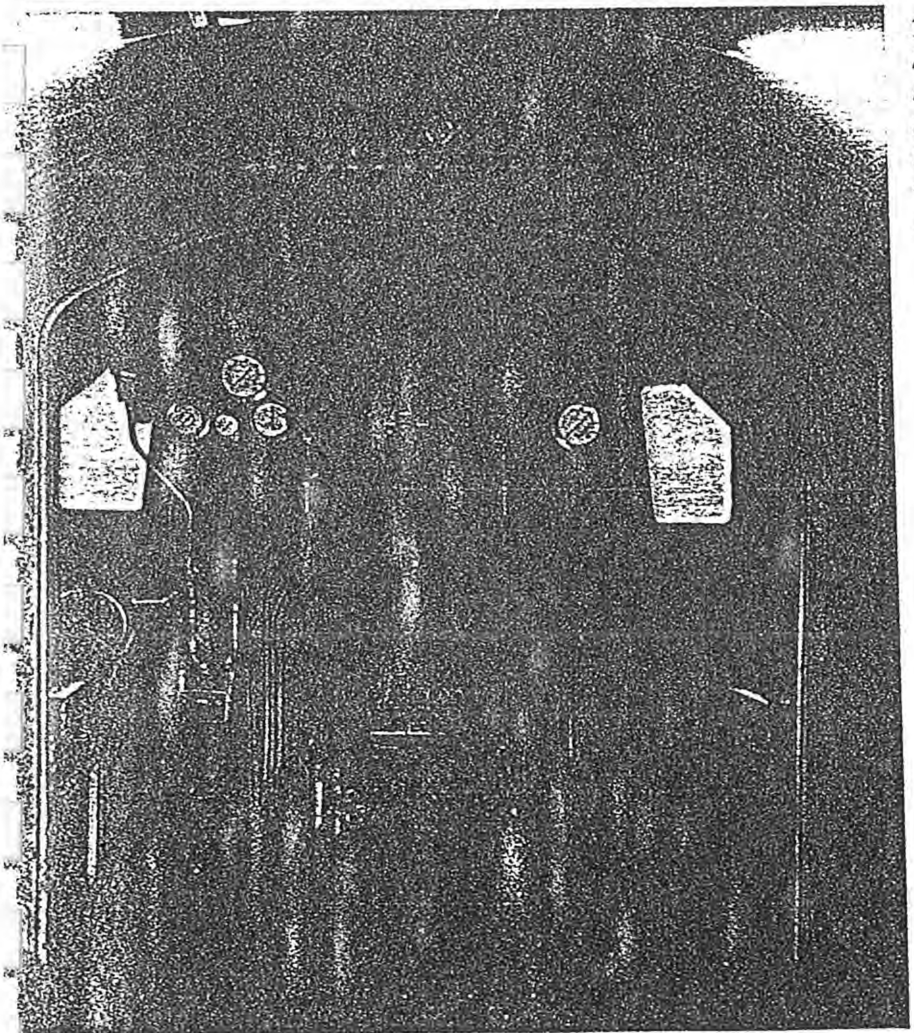
Ahead of the driver were two gauges to register the pressures in various brake cylinders and reservoirs. Two other gauges were provided for boiler pressure and cylinder pressure. From the reading of the latter, the operation of the pilot valve was controlled. The fireman was provided with a boiler pressure gauge only.

The fireman had small wheel-operated valves regulating the steam supply to the blower and injector. A valve to his right controlled the hot water hose used for washing the cab floor and for dampening the coal to minimise dust.

Between the two crew, twin gauge glasses were mounted on the back of the boiler and indicated the level of water in it. Below it, the firehole door could have its twin "butterfly" doors manually opened or worked from a pedal in the cab floor. This was a valuable feature when working hard and the fireman thought he was working harder. Every time the door opened, cold air was admitted which lowered the heating process. By using the pedal, the fireman controlled the time the door opened to just enough to admit each shovelful of coal to the fiery furnace.

On the floor were the twin levers and links to rock the various sections of the grate.





The 38 class locomotives not only had to haul their intended trains, they also had to be compatible with the existing servicing facilities where-ever possible. Turntables were a case in point and the black 4-6-2 is rotated at Goulburn in 1960, 3628 and 5239 also resting between jobs
Photo: Mick Farrell

The controls in the crew's cab as first constructed in 1943.
Photo: State Rail Archives

A valve on the top of the boiler controlled steam to the ırbo-alternator to supply the electricity for lighting. The itches for this system were on the ceiling above the driver.

Electric lighting had been introduced to NSWGR locomo-ves in the early 1920s. For the 38 class, the latest equipment as to be used. The steam powered alternator was from Stone & Co. and provided 500 watts of power at 36 volts. ..e headlight, centrally mounted in the streamlined nose, sed much of this power while marker lights, one on either le of the smokebox and two on the back of the tender, ovided for train identification. In the cab, a light in the eiling allowed the crew to see their way at night. Another ir of fittings illuminated the water level gauge glasses while other lit the driver's gauges. At ground level, the steps and main siderods were illuminated for crew access and mainte-ance. In the tender, a fitting on the back lit the water filling le when water was taken at night.

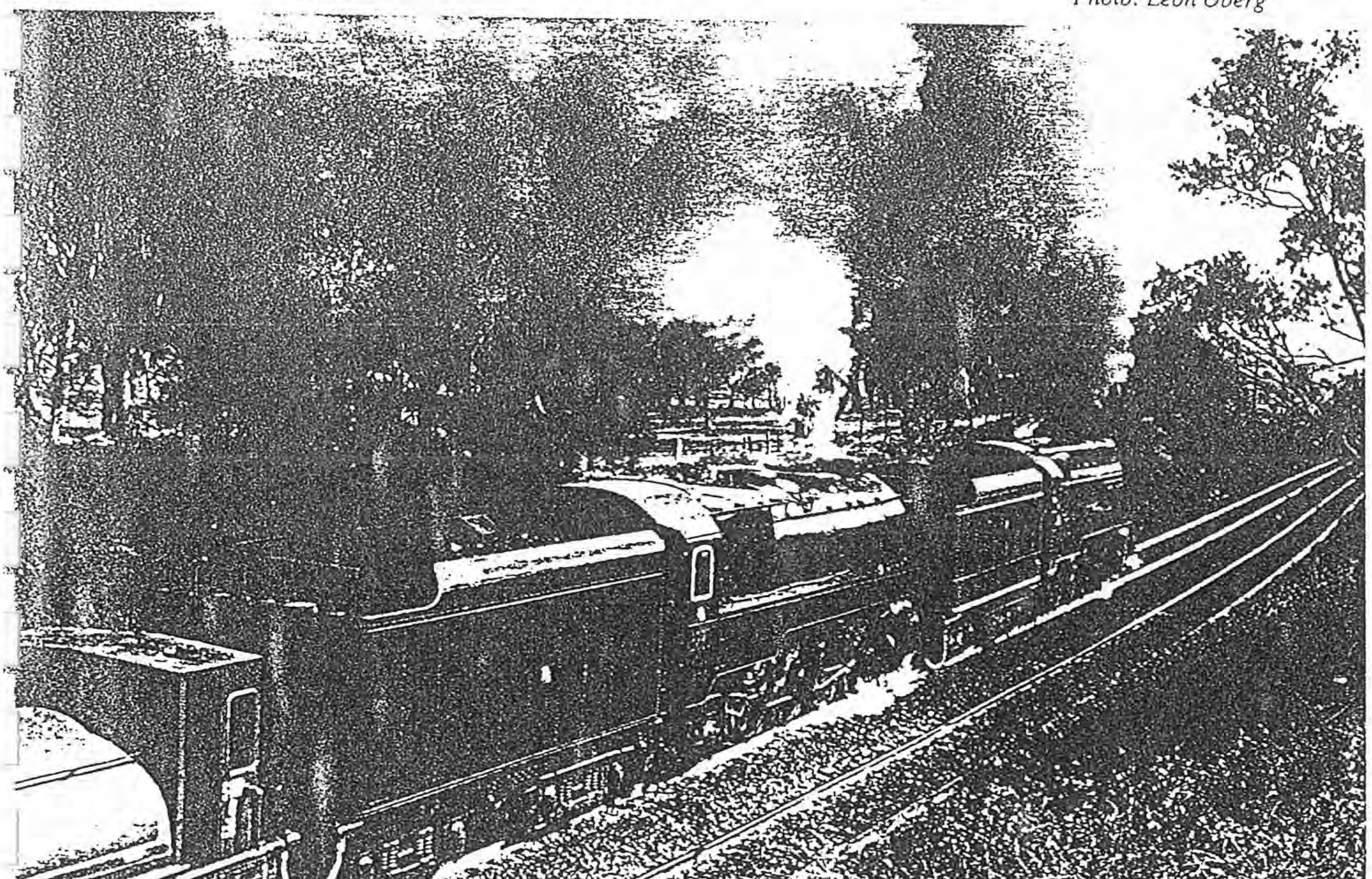
When ready for the road, the engine unit tipped the scales t 112 t 4 cwt (114 002 kg). The engine wheelbase was 33'3" 0 134 mm) and the rigid wheelbase 12'2" (3 708 mm).

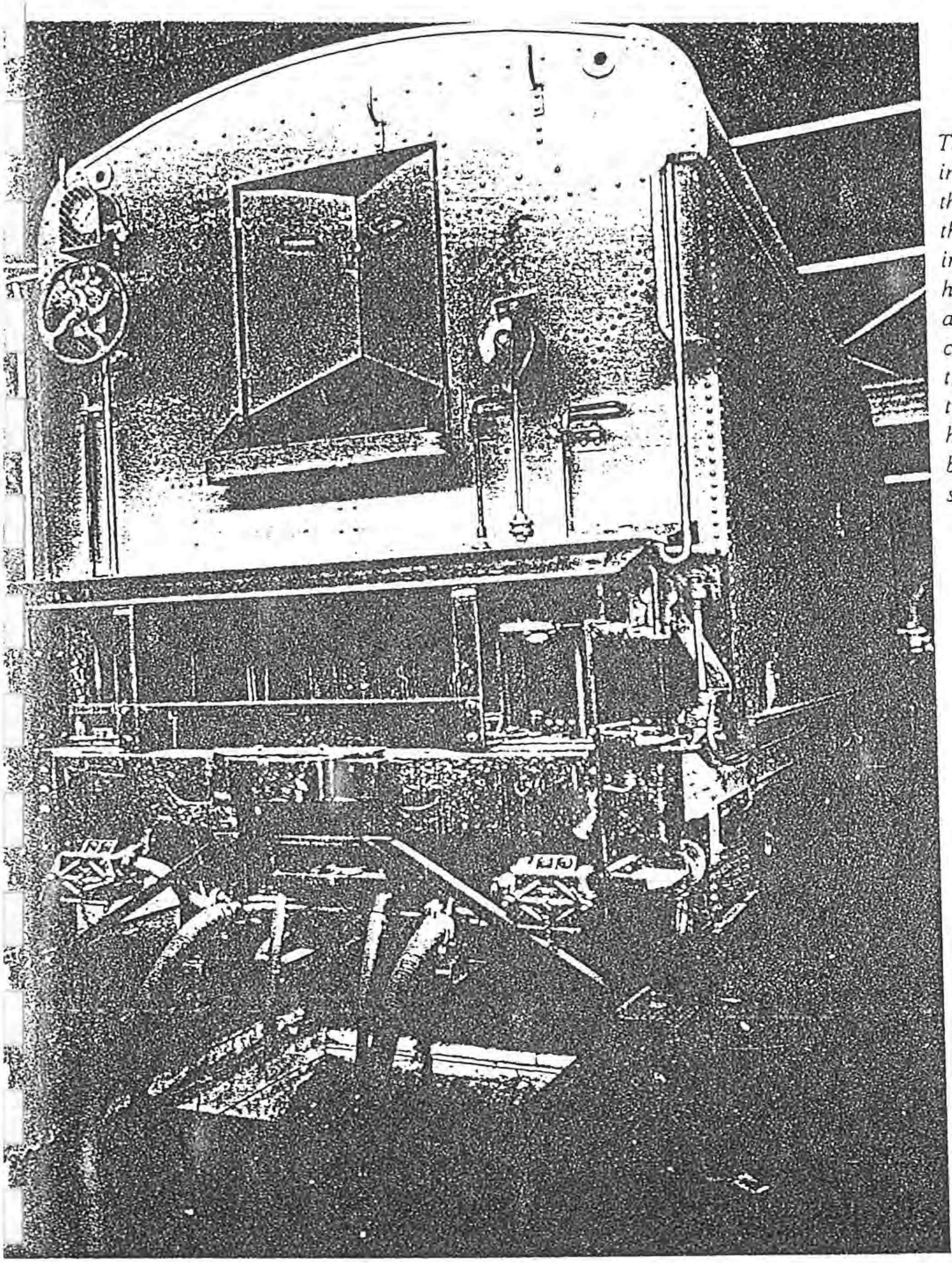
Behind the engine came the tender and this too required areful calculations. Again equalised cast four-wheel bogies itted with roller bearings were used under the fabricated frame with cast buffer and draw-bar beams at either end. Above was the steel tank which had to provide for the coal and water needs of the powerful loco as it sped through the country. Water was available at many points but stopping too often to replenish was to be avoided. Certainly, it would be desirable to operate non-stop between Sydney and Newcastle as well as running to the depot at each end of the trip and this volume of water would be a minimum requirement. Coal was the other essential. It was not as readily available as water and usually had to be taken in a depot where coal stages were provided. This meant uncoupling from the train with resulting delay.

The Melbourne Expresses were, perhaps the most important duties planned for the Pacifics. On the run south to Albury, a large coaling facility had been built at Demondrille near Harden specifically to minimise the hauling of coal to Albury, the end of the trip for the 36 class which up until now had operated these trains. It also allowed the locomotive to be serviced on the train and for it to run right through the 399 mile journey unchanged. Consequently, the tender of the 38 had to contain sufficient coal to run Sydney to Demondrille with the heavy expresses and also to operate the Demondrille - Albury - Demondrille run.

:oal and water supplies were calculated so that the 38 class could operate the expresses on designated routes using the facilities en available. In current operations, it is often necessary to carry additional water in "gins" and pump it through to the comotives to meet demands. 3801 and sister 3820 head south with a tour train en route to Melbourne in April 1973, a bogie ater tank ensuring adequate supplies.

Photo: Leon Oberg





The deck of the tender showing the shovelling plate and the handles which control the supply of water to the injectors. On the right is the handle and gearbox to operate the automatic staff exchanger used when travelling express on single track routes. The "ram's horn" to collect the staff can be seen adjacent to the third step.
Photo: State Rail Archives

The last requirement was that the vehicle had to weigh no nore than the maximum which four axles could carry without xceeding the axle load set down. In any case, the lighter the ight, the greater the load which could be hauled and the appier the fireman would be.

When all the calculations were done, 14 tons (14 224 kg) coal could be taken together with 8100 gallons (36 450 l) water. The total weight was 89 tons (90 430 kg). Like the locomotive, two standard "Turton" type buffers were ounted on the buffer beam and standard heavy hook awgear was provided. The two locomotive units were inked with a unit drawbar with safety link. Radial buffing gear maintained nominal contact between the two units and nsured a smooth ride.

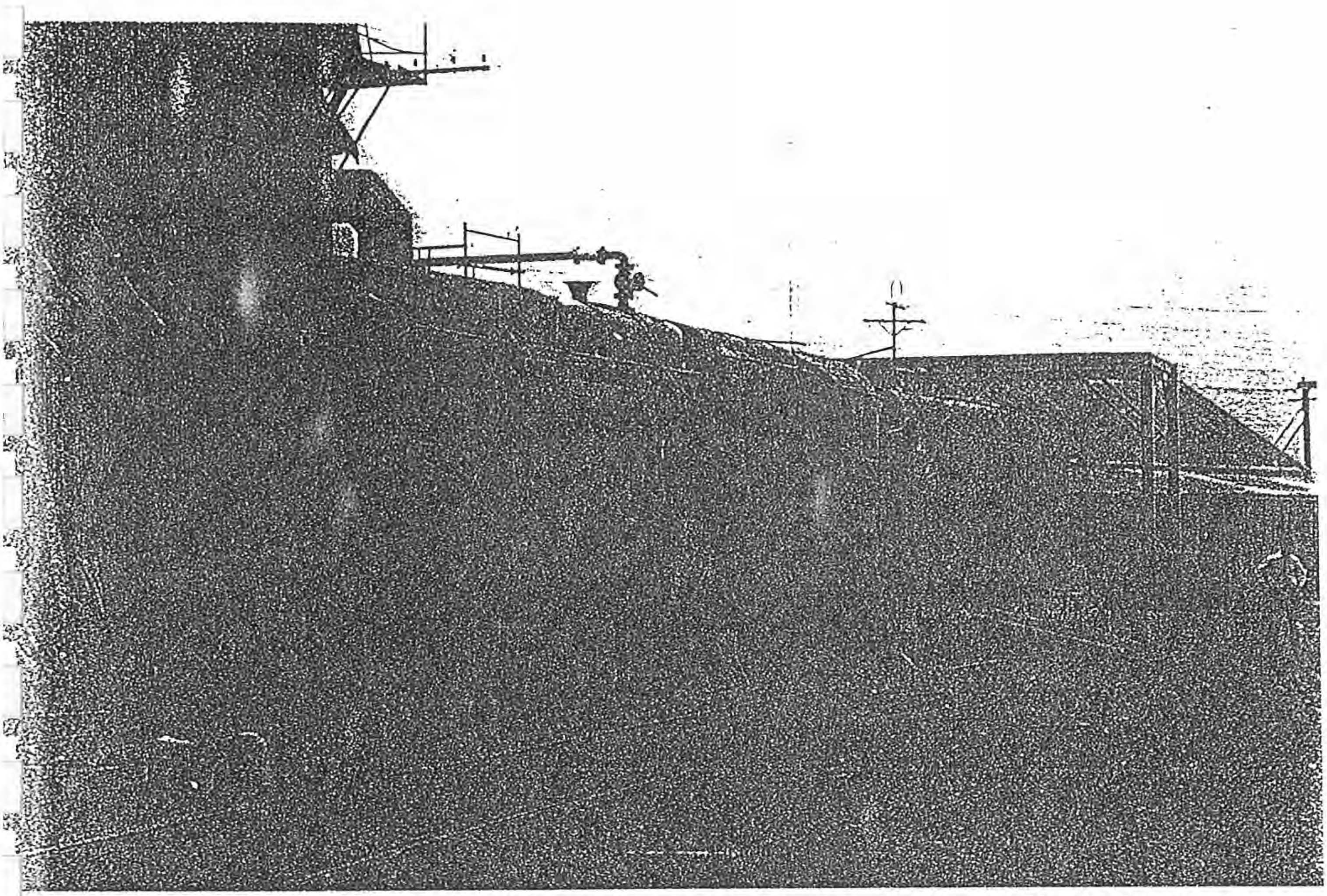
An innovation in the tender braking system was a hydrostatic valve which altered the brake cylinder pressure as the vater level dropped. As the load became lighter, the braking forces were also reduced else wheels skid under heavy braking and reduced adhesion mass.

A hand brake was provided on the tender for stabling the locomotive in depots. On important expresses, the number of stops on single lines had been reduced by fitting exchangers which picked up and put out the safeworking staffs which authorised the train to proceed through a section. Such a staff exchanger was mounted on the tender and was operated from its footplate on the driver's side.

Steps to gain access to the footplate from ground level were provided on the tender only.

When fully fuelled and ready for the road, 3801 measured 76'4⅝" (23 282 mm) over its buffers and weighed 201 t 4 cwt (204 432 kg).

The total wheelbase dimension was 65'7⅛" (19 992 mm) which met the design criteria of being able to turn on the 75' turntables which were in common use.



One of the last acts for 3801 before its "final" withdrawal, was to act as a stationary source of steam at Homebush Abattoirs in 1968. The high pressure boiler at these works failed and, to keep up production, 3801 was requisitioned. With temporary plumbing connected to its dome and an improvised funnel attached above the smokebox, another challenge in the Pacific's long career was met. *Photo: Fred Saxon*

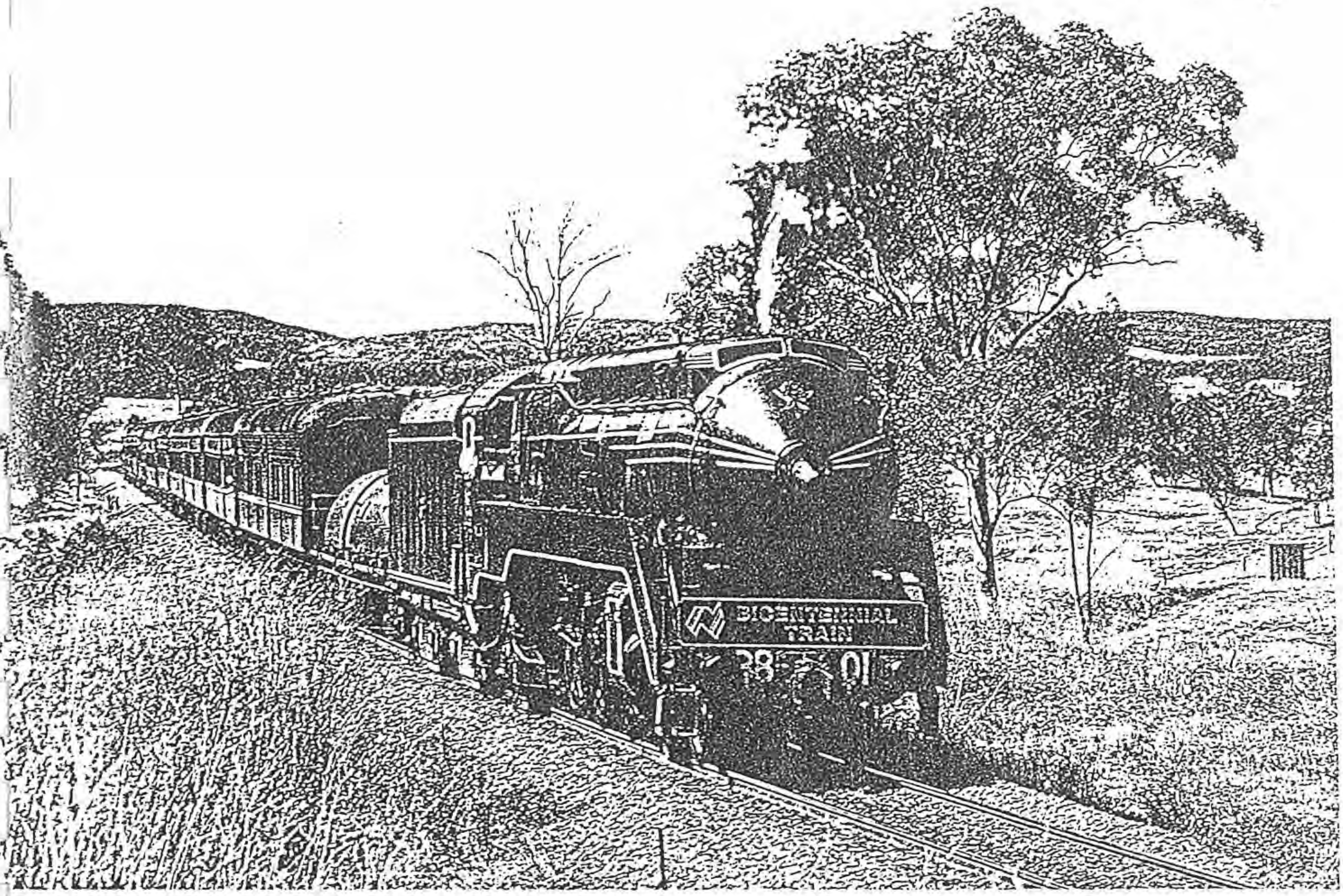
RESTORATION

The idea of so famous a locomotive lying out of use occupied the minds of many. Overseas, many important designs had been restored, some after years of neglect, some snatched from scrap yards as the heat of the cutting torch was almost upon them. One evening in mid 1980, Professor John Glastonbury, now Chairman of 3801 Limited, was dining with David Hill, Chief Executive of the State Rail Authority. The subject of the famous locomotive was raised and all at the table agreed that it would be a "nice idea" to restore the 4-6-2. This germ of a proposal was not lost and soon after Doug Neil, a former Chief Civil Engineer with the Railways, convened a group of interested people to investigate the possibility of a complete overhaul. Such was the progress, that several meetings were held and a feasibility study ordered.

Consequently, the long road back from storage to active service started in the early hours of one November, 1980 morning as David Hill made his way from the dinner at the conclusion of a conference. On the steps of the Wentworth Hotel, the subject of 3801 was raised with the Assistant General Manager of the Railway Workshops, Bill Casley as he too was making his way home. The assurance was given that if the locomotive was to be restored, the expertise necessary was still available in Railway Workshops. With considerable forethought, the Chief Executive was planning for the Bicentenary of European settlement in Australia and for the steam locomotive, which had played such a vital role in the development of the country, to represent the rail industry in the celebrations. Dutifully, the promise was made to the Chief that the idea would be completely investigated to determine its feasibility.

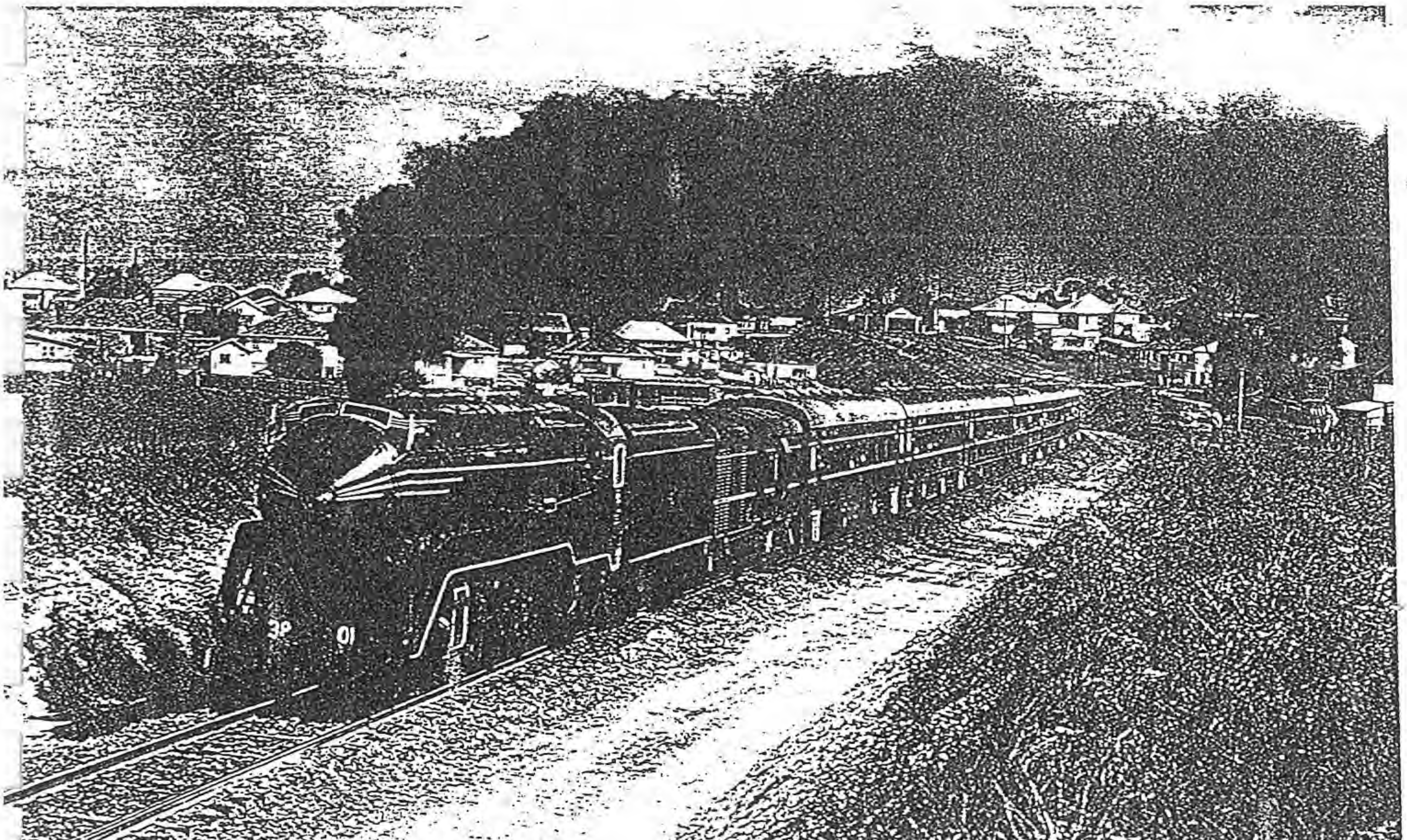
The first step in the process was to find what modern technology could do for the badly neglected boiler, the key factor in the restoration. It had been boiler condition that had taken 3801 out of service so it would be boiler repair that would return it.

The South Maitland Railways whose headquarters were at East Greta Junction near Maitland were not only still operating steam locomotives in regular service, they were repairing boilers using welding techniques unknown in the Govern-



he delightful country of the NSW North Coast was one of the attractions enjoyed by those privileged to take part in the return from Brisbane of the Bicentennial Train. With headlight gleaming, (above) 3801 canters through the valleys near Oakhampton. ome local runs are made for those attending the Maitland Steamfest so that as many as possible can sample the delights of team train travel. A trip to Paterson on the North Coast Line (below) is under way as 3801 leads its cars out of Maitland in 1991.

Photos: Stephen and Ron Preston



...boiler shops. To find what was possible, Bill Casley and author visited the East Greta Works on 13 May, 1981 and shown at first hand not only what was possible but what been approved by the supreme policy makers.

The findings were that South Maitland were, in fact, ...ring to service boilers that in years gone by would have scrapped. A boiler had even been constructed in their ...n shop using welding where once rivetting and other ...our intensive methods had held sway. This unit was in ...ce in their number 18, a 2-8-2 tank used regularly in the ...y coal hauling duties.

It was initially proposed that Cardiff Workshops near ...castle perform the work and a team was formed to carry the investigations. Just as the original design team had to ...ace enormous emphasis on the boiler, so the investigators ...marily needed to know if a suitable boiler remained among four 38 class that were extant. This quartet comprised ...01, 3820 and the last member of the tribe, 3830, all of which ...ere stored at the Rail Transport Museum at Thirlmere. The ...er "remaining" Pacific was 3813 which had been taken ... Eveleigh Works in 1973 for an overhaul with the idea of ...ing it in tourist traffic. Unfortunately, after the 4-6-2 had ...n completely stripped, the Chief Executive of the then ...blic Transport Commission, Mr. Phillip Shirley made an ...nspection. Despite the fact that it was his more respected ...eputy who had arranged the overhaul, the Chief Commis-...ner immediately ordered the removal of the locomotive. A ...ngthy string of goods wagons was ordered to store the ...undreds of parts while the boiler shell and main frame were ...en to Clyde and unceremonially dumped in the grass there ...waste away while the elements took their toll.

The Cardiff team included the Workshops Chief Foreman, ...n Crossley, a boilermaker by trade who had forgotten more ...out boilers than most others could remember and who had ...njoyed a lifetime association with steam. The next member ...vas Mechanical Engineer Len Howell who had served his ...ne on steam. The Works Manager of Cardiff also made the ...urney.

The trip to Thirlmere was made one gloomy day, 1 July, ...81 in the company of the General Manager Workshops, ...en Heard, nephew of Mr. F.P. Heard, a Chief Mechanical Engineer under whose regime the 38 class were largely ...replaced by diesel-electric units. His Assistant G.M., Bill ...asley, one of those investigating the proposal, was there too.

At Thirlmere, the condition of the three locomotives was determined. The Museum's Restoration Manager, Jim Martin ...as on hand to assist in the investigations.

The final verdict was that the most suitable boiler and, indeed the most practical solution was to use the boiler ...lready in 3801. Ken's opinion at this stage was that the boiler ...arrel was in good condition but thermal fractures were apparent in the inner firebox and these were of first concern. The wheels on the locomotive were satisfactory with plenty ...f life left in the tyres while the various items of equipment ...vere complete and in place. None of the tenders examined was suitable for returning to service without extensive re-...pairs.

From these initial investigations, it was apparent that it was feasible to proceed but the new technology would be necessary if the firebox was in need of the heavy repairs that the initial audit had revealed.

Two committees were formed to control the complicated task of restoration. First, a Technical Committee was convened to monitor the progress of the mechanical aspects of the locomotive. Not the least of these was the repair of the boiler and the technology of this operation was one of its prime concerns. Here John Glastonbury, as Dean of the Faculty of Engineering at Sydney University brought his expertise to bear while Stan Ambrose, Chief Inspector of Pressure Vessels with the Department of Industrial Relations, was also involved. The other group was the Restoration Committee under the chairmanship of Doug Neil. Here the budget aspects of the assignment were of prime concern while the generation of funds was another. A restoration appeal was launched and publicity was organised.

Any doubts on the possibility of restoring 3801's boiler to again breathe life into the engine were dispelled. What would not be easy would be to convince the traditionalists.

It was at this stage that various pressures on the railways resulted in implications for the project. The maintenance of the diesel-electric locomotive fleet was creating demands on the maintenance facilities, especially the workshops.

At this time, some companies were reducing staff and numbers of apprentices were placed in the position of not being able to complete their indentures. This situation was being overcome mainly by the formation of the Hunter Valley Training Company whose role was to take in these young people and continue their training until the opportunity came for them to be placed back in the regular workforce. Naturally, useful work had to be found for these apprentices to perform and the Department of Industrial Relations was charged with the task of monitoring the operation of the scheme. Representatives of the Apprentice Directorate, under the guidance of Kevin Harper examined the feasibility of the 3801 project after which the decision was taken to take the Pacific to Newcastle for restoration. The project would provide work which engendered a sense of purpose and would be performed by the Hunter Valley Training Company at the State Dockyard at Carrington alongside the banks of the Hunter River. The driving force behind the Company were its Chairman, former Minister for Transport, Milton Morris and its Manager, Kay Sharpe. From the technical point of view, Technical Manager Arthur Soennicshen would plan and implement the restoration while his seven Supervisors instructed the many apprentices who would perform the various tasks. Some of the funding would come from Federal and State Government grants, monitored by the Apprentice Directorate. The remainder would have to be raised.

Various companies including the locomotive's builder, Clyde Engineering, came forward with donations to finance the venture and generous support came in donations of material.

To help finance the project, 3801 was marshalled ahead of a string of cars and passengers were invited to make the trip

..e big 4-6-2 was hauled from Sydney to Newcastle.

On the afternoon of Sunday 20 November, 1983, a badly ...ered 3801 arrived at Newcastle behind modern diesel ... and was hauled away by a 73-class.

The next three years saw many problems raised, solved ... overcome. Paramount to the success of the undertaking ... the rebuilding of the boiler. A thorough inspection ...owed the inner shell of the firebox was so badly cracked ...t replacement was the most obvious solution. This was ...in territory for such a transplant had never been necessary ...he steam era. Further, all the dies and jigs which had been ...de to produce the complicated steel pressings that formed ... boiler had long since been turned into scrap.

During the first week of August 1984, the old firebox was ...moved and used as a model on which various companies ...uld base calculations and designs. The famous boiler fab...ating firm, Babcock Australia Ltd, was the design consul...ants. From its investigations, it was decided that the large ...x-like assembly could be fabricated and welded as the ...horities had agreed. E.R. Curtin Pty. Ltd. received the ...der to manufacture the new firebox. The use of welding ...sturbed the conservatives of the Railway Boiler Section and ...uld continue to do so throughout the project. In the original ...sign, the pressings used had rounded corners and were ...mmetrical with the outer box especially in the lower, front ...rners. The fabricated box could not easily match the outer ...x faces and a compromise had to be reached. A stringent ...ode lays down the design criteria for boilers and in this ...designed firebox, sufficient stays could not be grouped in ...e front corners to support the original boiler pressure. When ... the calculations were done it was possible only to authorise ... pressure of 215 psi (1480 kPa) to conform to the code.

With the project now well under way, the question was ...ised as to how the locomotive would be managed when it ...eturned to service. A professional, business approach would ...e needed so the company now known as 3801 Limited was ...nceived and formed. It took over the role of fund raising, ...ven seeking advice from the Fund Raising Council of Aus...ralia.

The role of technical advisors to the Company fell largely ... the staff of Cardiff Workshops. For the boiler aspects, Ken Crossley provided a wealth of experience and even made ...isits in his leisure time to help the delicate work of installing ...he new firebox. A major problem became apparent when the ...plain, undrilled new inner firebox was delivered in May. Literally hundreds of holes had to be drilled to exactly match ...he existing holes in the outer case. Together, Ken Crossley ...nd Arthur Soennicshen devised an ingenious solution and ...he firebox was successfully installed in August, 1985.

By December, the various components which are mounted ...n the main frame had been assembled and the frame cleaned and painted.

Other components needed special equipment. The large driving wheels, for example had to be turned to restore the correct profile to the running surfaces. This required a wheel lathe and all wheels were taken to Cardiff Workshops for turning. While there, the opportunity was taken to examine the large roller races on each axle using staff who had the experience to carry out this specialised task. Blemishes were found in the rollers and the size of the indentations created doubts in the minds of the fitters. Had they encountered blemishes of this size before? What could be repaired? What should be condemned? Time had taken its toll of the knowledge. Certainly if an incorrect decision was made, the results when the loco ran again could be disastrous. Assistant Works Manager Reg Farnham headed for his cupboard and some time later appeared with a dusty volume in his hand. Rescued from an obscure corner, it described not only what blemishes could be allowed but also how to repair those that exceeded the limits.

While this debate was in progress, an engineer from Sydney arrived and was drawn into the discussions. With him was one of the conservative boiler staff who was approaching the welded firebox in full reverse gear. Finding that another problem threatened the project he quietly entreated the author to "put the oxy through the axles and end this stupidity".

Arrangements were made to modify his thinking!

Early April 1985 saw the tender frame cleaned and repaired. However, long service and exposure to the elements had rusted the tender tank and a new one had to be constructed.

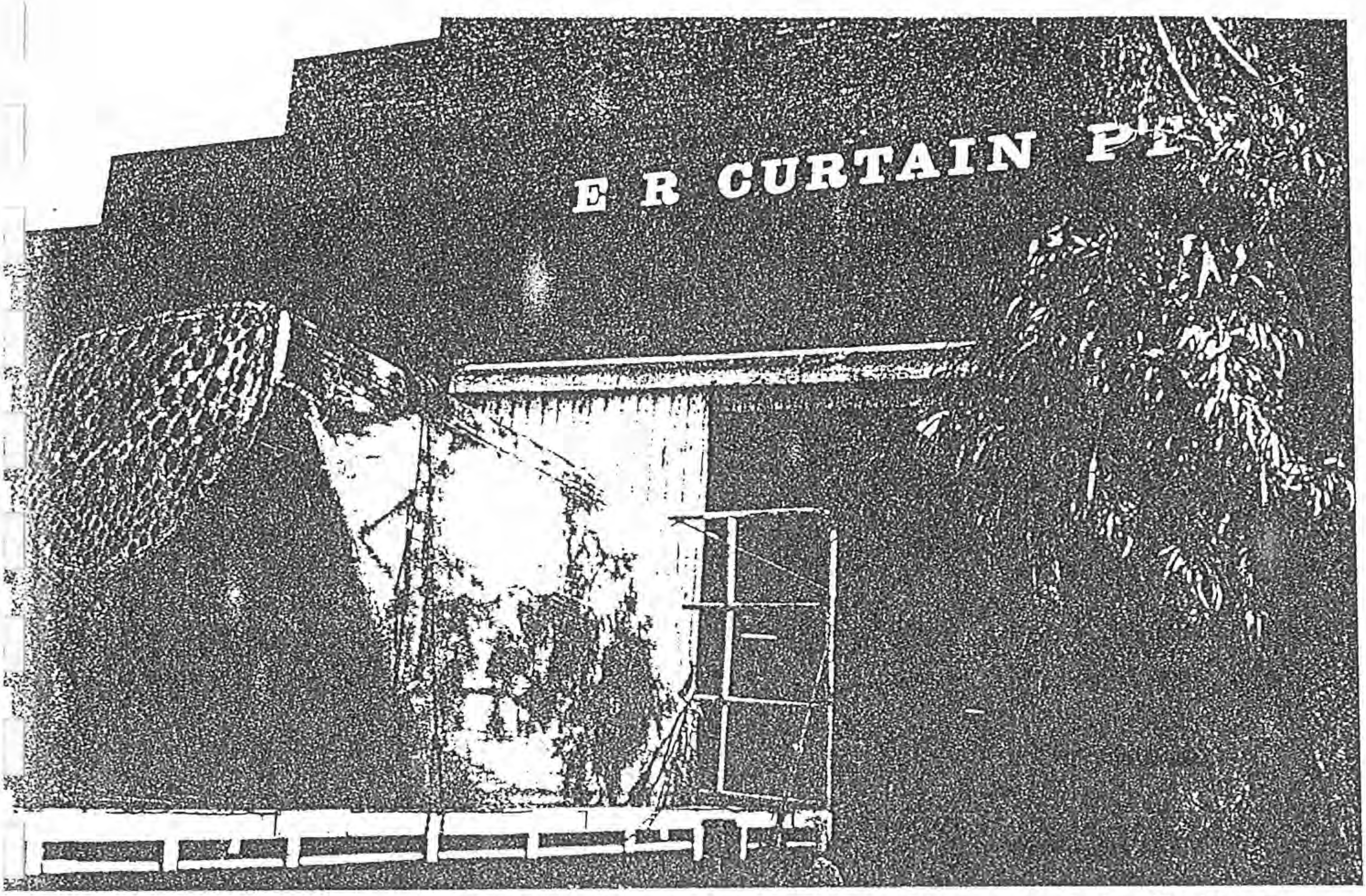
On another occasion, the Dockyard asked for help in applying the special bearing metal to the slidebars. This task had been the role of coppersmiths and there were few of this trade left. One such employee was Ray Harris, who was the President of the Combined Unions. The author asked for his help. Ray promptly rattled off a list of requirements and transport was arranged to the Dockyard.

"Gather 'round boys" was Ray's only remark to the apprentices who gathered to watch the process. Then, with flux flying and wielding a large oxy torch in almost lethal fashion, Ray put on a demonstration of the art of remetalling that gave the impression that it was still common practice every day.

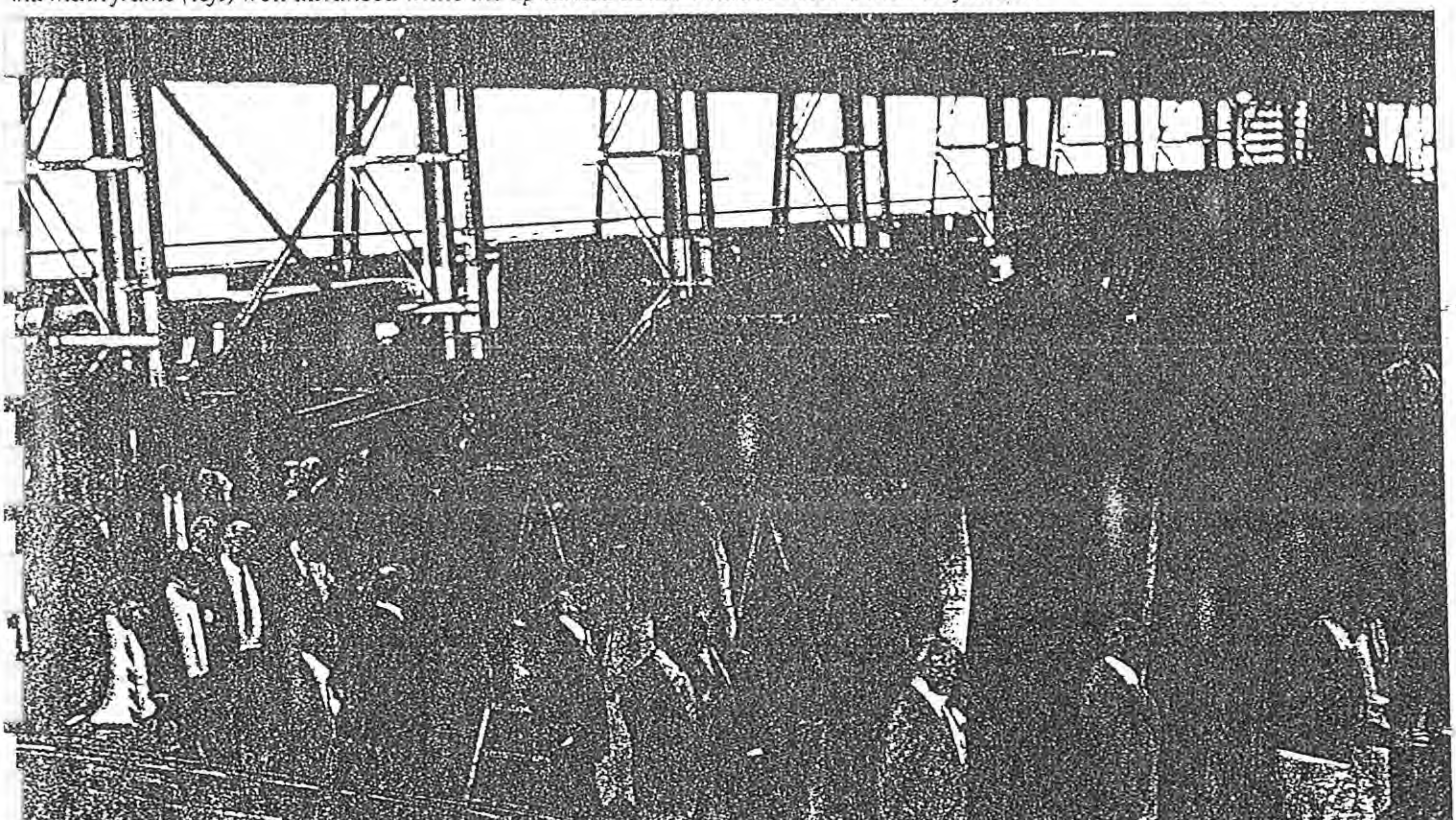
When it came time to overhaul the regulator assembly, the oldest employee was singled out as the past authority. When the electric lighting had to be rewired, an office worker dug out his overalls to lead the team.

Air brakes require specialist knowledge and Apprentice Instructor Joe Huntly had been an expert in the field before taking on his tutorial role. Joe was also Secretary of the Lake Macquarie Live Steam Locomotive Society and an unrestrained steam buff. When offered the job of guiding the air brake repairs, he was off like a shot, the breadth of his grin only marginally exceeding the enthusiasm he brought to the task.

In the meantime, the decision to build a new tender tank using welding resulted in an unusual problem that required a well considered answer. With rivetted construction, the heads of the fastenings had been prominent features on the original sides but welding gave a plain finish. Much debate followed. One proposal was to fix artificial rivet heads on the sides but problems were envisaged in future maintenance. Finally John Glastonbury, Chairman of the Company formed to administer the future of 3801, announced that it had been decided that a



he most vital operations in the restoration of 3801 were the manufacture and fitting of the new inner firebox. The fabricated ..eel vessel (above) is loaded ready to leave its manufacturer while invited guests, sponsors and other onlookers inspect the ..oiler at the State Dockyard (below). Apprentices from the Hunter Valley Training College have the tender tank (background) ..nd main frame (left) well advanced while the up turned boiler waits to receive the new firebox. *Photos: State Rail*



ain sided tender was better than no tender at all.

Throughout the working weeks, the apprentices reconditioned the hundreds of parts and components under the guidance of Arthur Soennicshen and his team of Instructors. Here another difficulty became apparent. The aim of the Hunter Valley Training Company was not only to help apprentices complete their apprenticeship, it was also to help place them back in the workforce. In this latter role they were extremely successful and the turnover of the apprentices slowed the progress. At times, staff from Cardiff were loaned to help some vital aspect of the restoration.

The critical superheater elements arrived at the Dockyard November, 1985 and the task of assembly of the many parts continued during the coming months. The major components were put in place in relatively short time but the fitting of the numerous detail pieces proved far more time consuming.

On some weekends, train loads of visitors would come from Sydney for inspection tours guided by Arthur and assisted by volunteers. It was not unknown for club groups to request an inspection during the week and Film Australia used the work site to place the author in the midst of the overhauled driving wheels to introduce a video production. The project had captured the imagination of the public.

Plans for painting took shape in May. Here the schedule had to be carefully co-ordinated to avoid the Tech College holidays.

Finally, at 4am on Saturday 8 November, 1986, members from the Rail Transport Museum struck the first match to warm the firebox in ten years. Steam pressure slowly rose and with the resulting strain some minor leaks were found. The fire was dropped and the boiler allowed to cool.

Next morning an early start was made to roll the leaking tubes and the fire was relit at 8am. By afternoon, steam had been raised and the loco was tentatively moved a few feet inside the shed.

On the Monday, 3801 was steamed again and made short runs up and down the nearby sidings. So far, so good so a trial run was made to Kooragang Island. Still in undercoat, the big Pacific ran to Maitland and return the following day.

An examination after this "shakedown" showed the need to repack the front truck to adjust the coupler heights. While this was being done, apprentices from the painting trade course moved in and the engine slowly returned to its former glory.

On the Friday afternoon, Broadmeadow Depot's Assistant District Manager Des Milton, issued the certificate authorising 3801 to again run on the tracks of the Railway that had given it birth, retirement and rebirth.

During the Friday night, the painting continued for the next day was to see the handover and official return to service.

Saturday, 15 November 1986 dawned fine and clear. The Newcastle Morning Herald included a special supplement and the media proclaimed the return of the "Newcastle Flyer" locomotive.

A special train brought invited guests from Sydney right into the Dockyard grounds. Thousands of people gathered to watch the Chairman of the State Rail Authority, Sir Lennox Hewitt, take delivery of 3801 from Milton Morris, Chairman of the Hunter Valley Training Company. David Hill, suitably clad in overalls, at intervals sounded the whistle from the footplate. After an official lunch, 3801 coupled to the carriages and proudly steamed from the Dockyard. The train of 425 tonnes was no match for the 4-6-2 but discretion said that the speed should be easy to allow bearings and other parts to "run in".

A speed limit of 50 kph had been set but, suitably urged on by the Chief Executive, Driver Clem Poetska allowed the speed to rise to nearer 90 at one stage. The train terminated at Maitland and 3801 ran around the triangle at Telarah to again face forward for the trip back to Newcastle. Drama hit the crew as they neared Hanbury Junction when both injectors failed to work. Inspector Fred Thompson said a few prayers, pulled a few handles and breathed a sigh of relief when both "came good".

A large crowd had gathered at Newcastle and Station Master Jack Way had made a banner of welcome. The locomotive was put on display and hundreds crawled around and, for some, through the cab. The crew gave autographs to all who asked and lumps of coal were handed out to the kids.

My task was to ensure the Pacific was locked up at Cardiff and as the passenger cars departed for Sydney, I tentatively approached Fred Thompson whom I had not met before and told him of my duty. "You're coming with us" was Fred's opening remarks. Never has anyone boarded a footplate so fast!

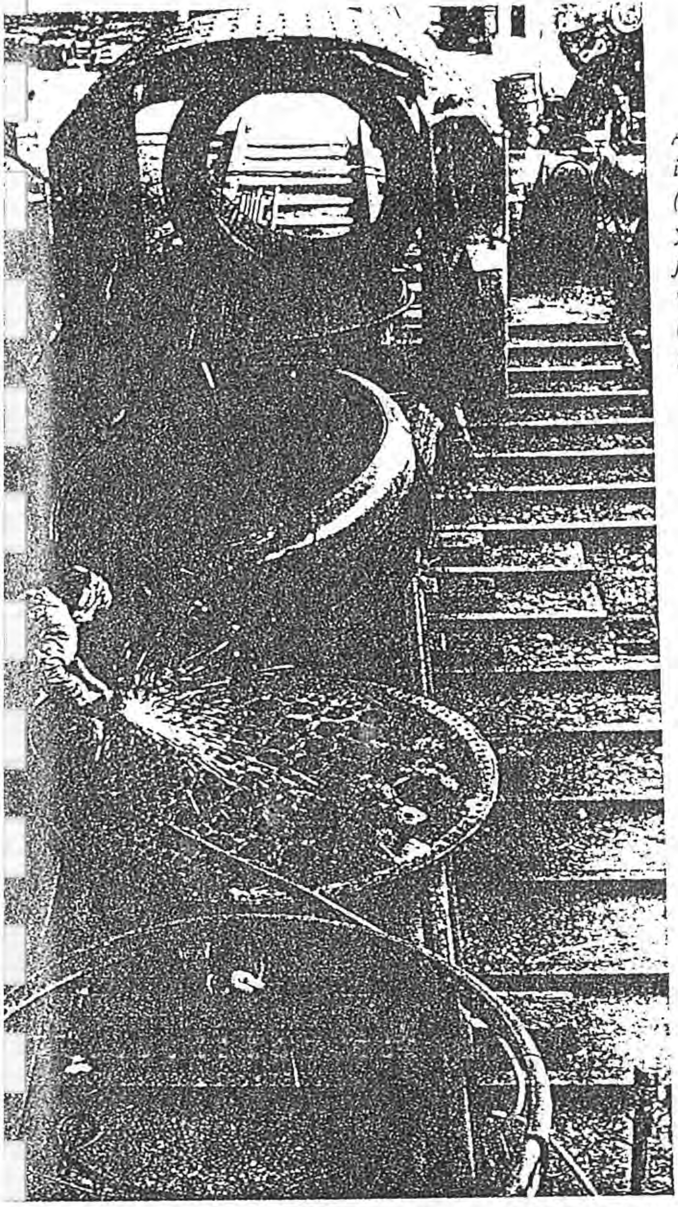
At 4pm with crowds still milling around, we left Newcastle tender first, proceeded towards Maitland and stopped on the Goninan Branch. Clem then steamed forward and we headed, funnel first around the other leg of the triangle into Broadmeadow station. Here we stopped in No.3 platform until an up interurban had made its way to Sydney. A prominent local politician approached with family in tow and rather humbly requested permission to inspect.

Once the signals cleared we headed on through Broadmeadow Yards and up the hill through Kotara. At the local Bowling Club, play stopped and white clad figures waved as we passed. The whistle sounded at regular intervals to announce our passing and in acknowledgement to all who waved.

At the summit, 3801 achieved another first when it became the first 38 class to pass through the new single line tunnel. Another novelty for the Pacific was the use of its crew to communicate with signal boxes by using a radio - unknown in the great days of steam. We rolled down through Cardiff with many people, including the author's family complete with dog, lining the fence to wave as we passed.

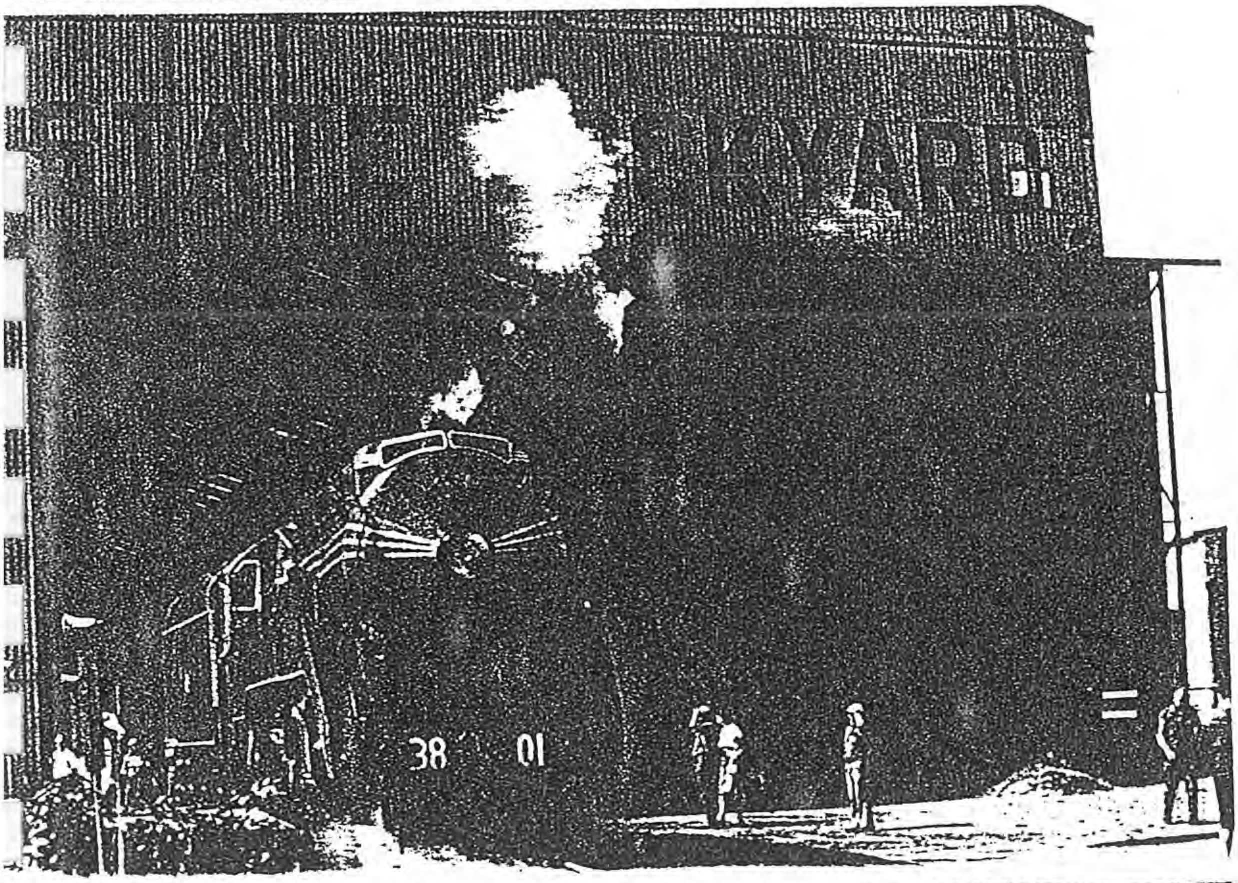
The fireman for the day was Dennis Agnew who was nearing the end of his career. He was so busy maintaining public relations and blowing the whistle that the mundane task of shovelling the coal was left to Fred.

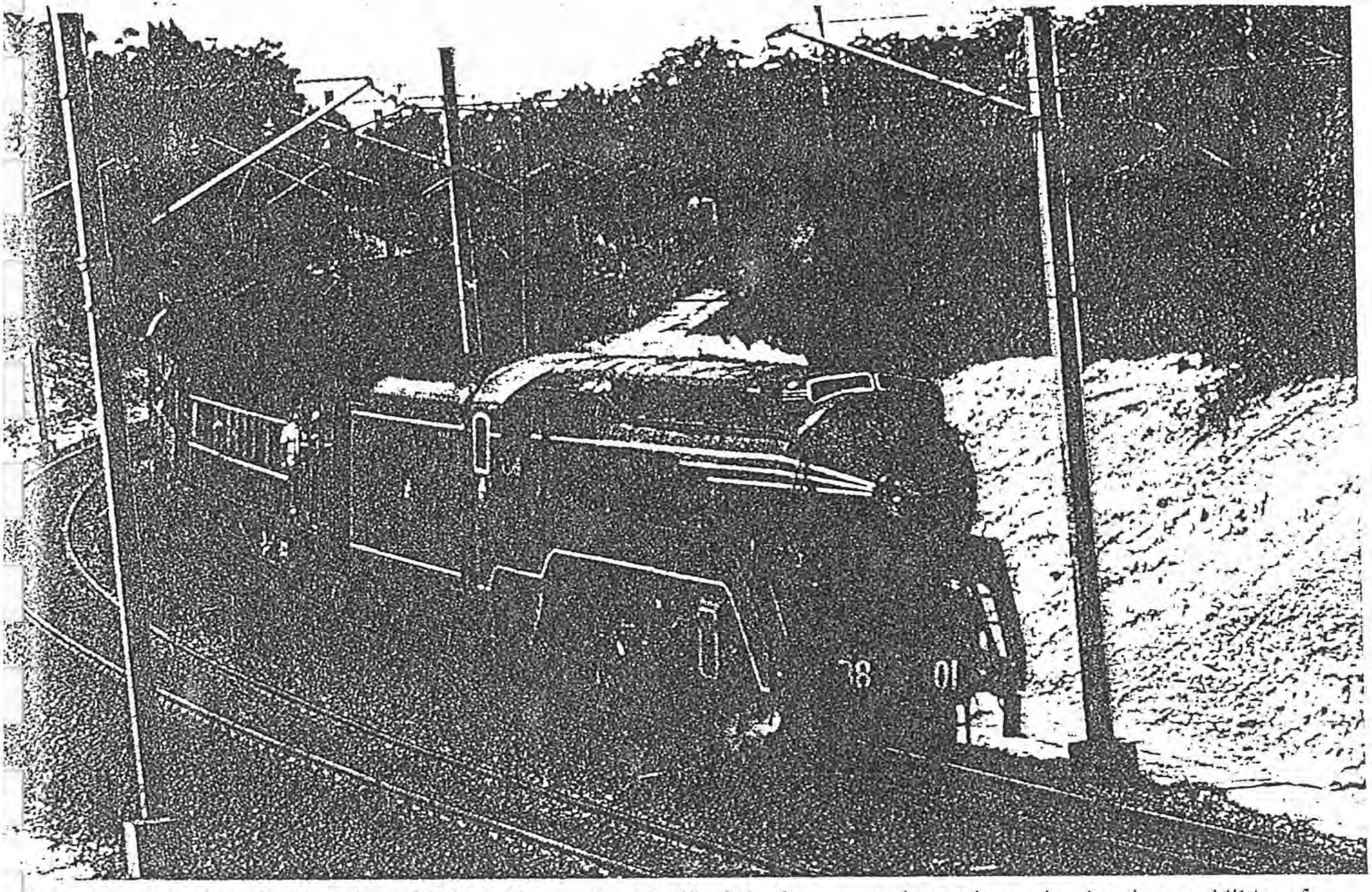
For Clem, this was a special trip in more ways than one for he was to retire at the end of the day. As we passed the Cardiff Railway Bowling Club on whose green a legion of ladies had stopped playing to wave, Dennis strolled over the



An apprentice from the Hunter Valley Training College grinds the front tubeplate of 3801 (left) during its restoration in the State Dockyard, Newcastle. The cab and other boiler fittings are lined up for repairs. A good job well done and 3801 again stands in steam (below) ready for the official hand-over on Saturday, 15 November 1986.

Photos: Leon Oberg and Stephen Preston





Vith a long train full of well-wishers, 3801 strolls over the 1 in 75 of Hawkmount, a clear exhaust showing the capabilities of the refurbished engine and its crew. The ultimate destination of this trip is the Grand Ball at Sydney Terminal Station.
Photo: Stephen Preston

The test was a success and the following day, 3801 ran to Chullora for another weighbridge check to ensure the weights were correctly distributed.

Friday 21 November, 1986 I travelled to Enfield Yard to join 3801 on its test run. At 10.30am we left with the Dynamometer Car, SFX, SBX, FS and MHO passenger cars and two freight guard's vans - a load of 238 tonnes.

We had a slow run to North Strathfield but then headed onto the main North line.

At West Ryde, we headed up the 1 in 40 grade in fine style in cold, wet and windy conditions. Chief Mechanical Engineer, Bill Casley to whom the project owed so much was on hand to add his personal approval. Bill ordered a standing start at Denistone and here disaster almost struck. Despite the load being lighter than the maximum, 3801 had extreme difficulty in gripping the rails. Worse, the rain had found its way into the sand pipes by the wheels and the sands would not run. A very slow start was made taking a long time with much wheel slip and lots of noise. Finally, the wheels gripped and with safety valves lifting the Pacific blasted its way up to Eastwood.

Once over the steep grade there was no stopping and with ever increasing speed we raced on to Hornsby where a stop was made to check what was wrong. The culprit was a hand brake in one of the vans - fully applied. 3801 had lifted a load far in excess of what would be expected in service.

From Gosford, a speed test was organised and, at 109kph we roared through Ourimbah. More fast running brought the 4-6-2 back to Newcastle. The test had proved its performance in all aspects.

Unfortunately, a lubricating oil line to the driver's side slide bars was blocked and the bearing metal had run. The loco was taken to Cardiff for repairs and trips for the public, planned for the weekend, were cancelled.

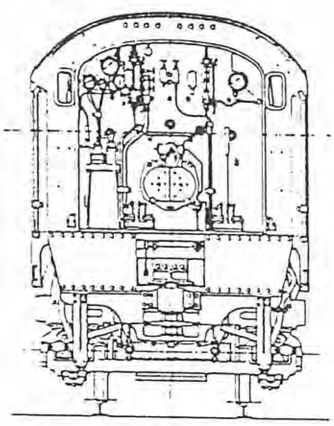
During the next week, the slide bars were repaired, the pipe unblocked and other minor repairs carried out. The loco rested for, on the Saturday, just like Cinderella, it was literally "going to the ball".

During his tenure as Chief Executive, David Hill had done much to promote the Railways and part of this publicity was to hold a grand ball using the vast concourse area of Sydney Terminal Station.

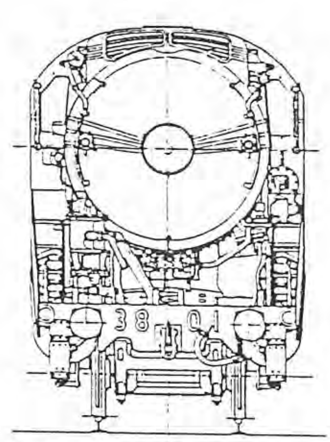
On the Saturday afternoon, 3801 departed Newcastle with a nine car special loaded with passengers. At Hornsby and other outer Sydney suburbs, these passengers departed and the 38 and its train proceeded to North Strathfield there to await its entry onto centre stage.

Finally, at the appointed hour the shiny, pointed nose of the green Pacific appeared out of the gloom of Sydney Yard, whistle blowing and headed into number 10 platform which offered the best access for guests at the ball, to a rousing reception.

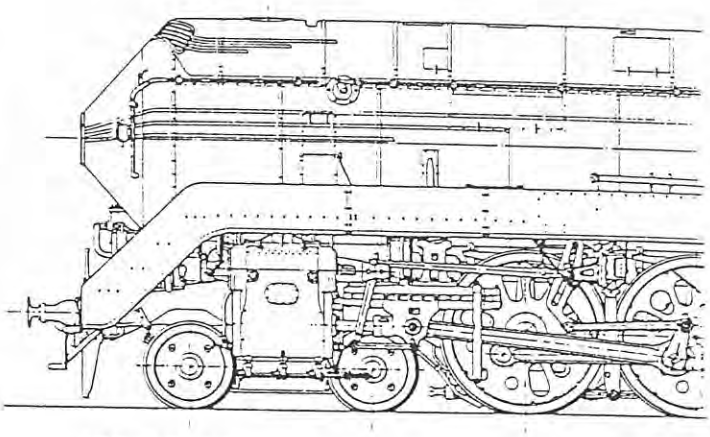
David Hill and those who had started the project almost six years before, joined with hundreds of others to officially welcome Australia's most famous loco in its return from oblivion and back into steam.



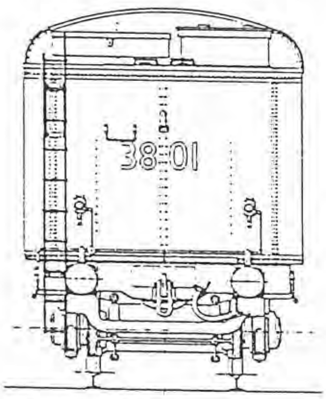
CAB FOOTPLATE



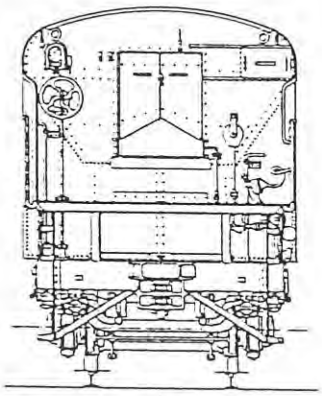
FRONT ELEVATION



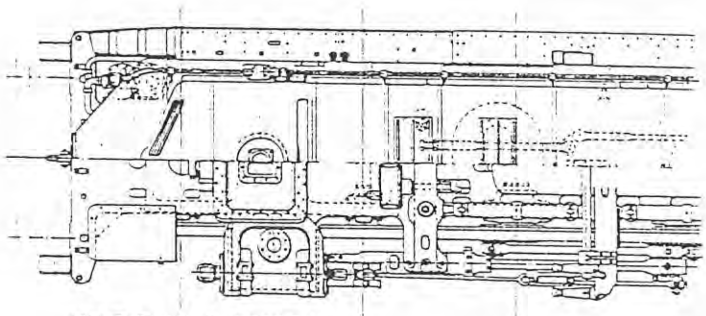
SIDE ELEVATION



TENDER REAR



TENDER FOOTPLATE



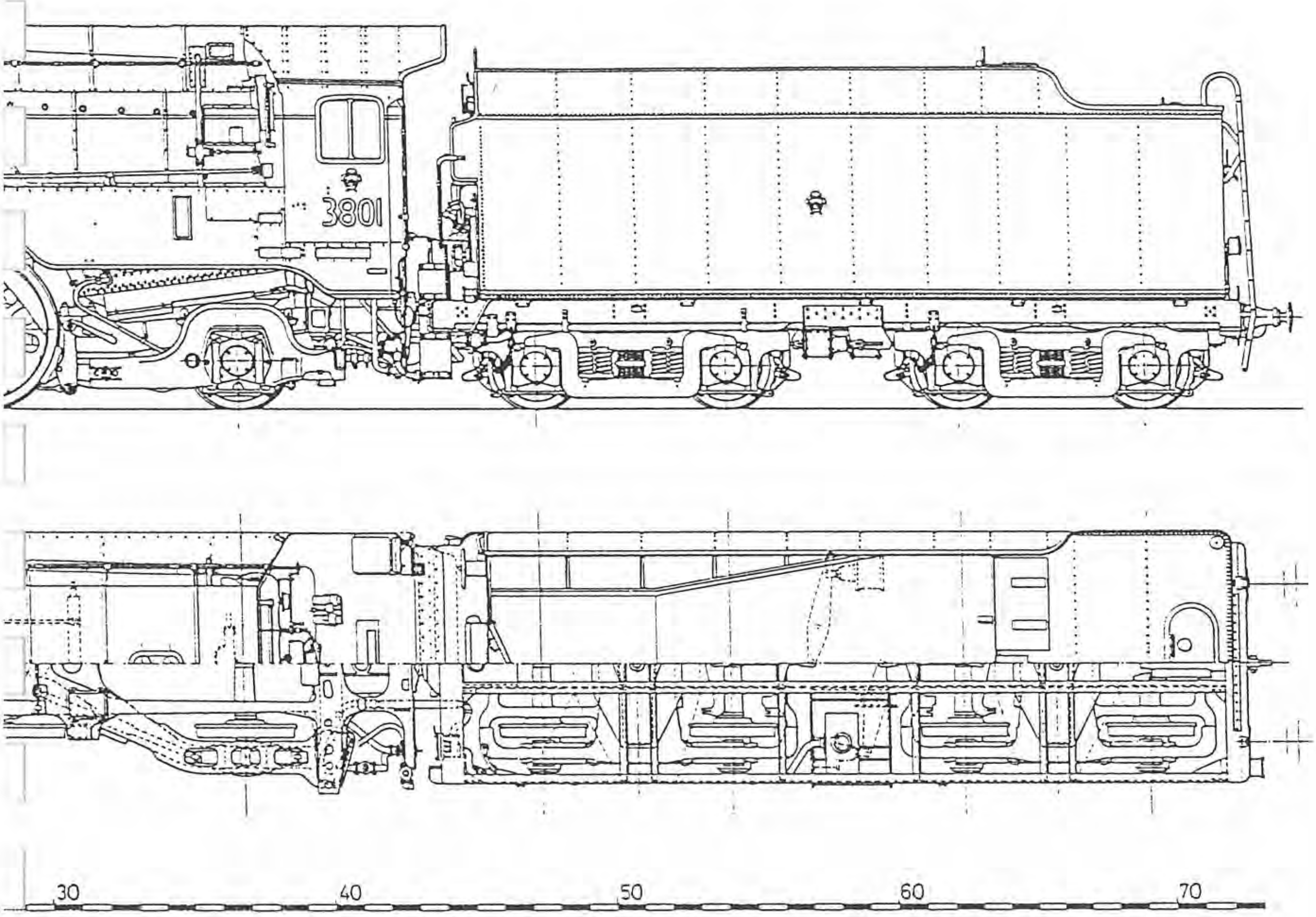
HALF PLAN & SECTION

Scale of Feet
0 10 20

DATA

Cylinders:	two	- 21½" diam x 26" stroke (546 mm diam x 660 mm stroke)
Boiler Pressure	- as built:	245 psi (1 688 kPa)
	- as restored:	215 psi (1 481 kPa)
Tractive Effort	- as built:	36,200 lbs (161 017 N)
	- as restored:	31,767 lbs (141 300 N)
Coal capacity:		14 tons (14 224 kg).
Water capacity:		8,100 gallons (36 450 litres)
Weight of engine in steam		112 tons 4 cwt. (114 000 kg)
	tender full:	89 tons (90 430 kg)

TOTAL WEIGHT in steam:	201 tons 4 cwt. (204.430 kg)
Length over buffers:	76'4⅝" (23 282 mm)
Total wheelbase:	65'7⅛" (23 282 mm)
Rigid wheelbase:	12'2" (3 708 mm)
Grate area:	47 sq ft. (4.32 sq m)
Flues:	36 x 5½" diam. (139 mm diam.)
Tubes:	142 x 2¼"diam. (57.1 mm diam.)
Arch tubes:	5 x 3" diam. (5 x 76.2 mm diam.)
Superheater:	36 element



(C)38

Diagram of 3801 as built.

HEATING SURFACE

Firebox:	224.58	20.66
Arch tubes:	26.70	2.45
Tubes & Flues:	2361.51	217.25
Superheater:	755.00	69.46
TOTAL:	3367.79 sq ft	309.82 sq m

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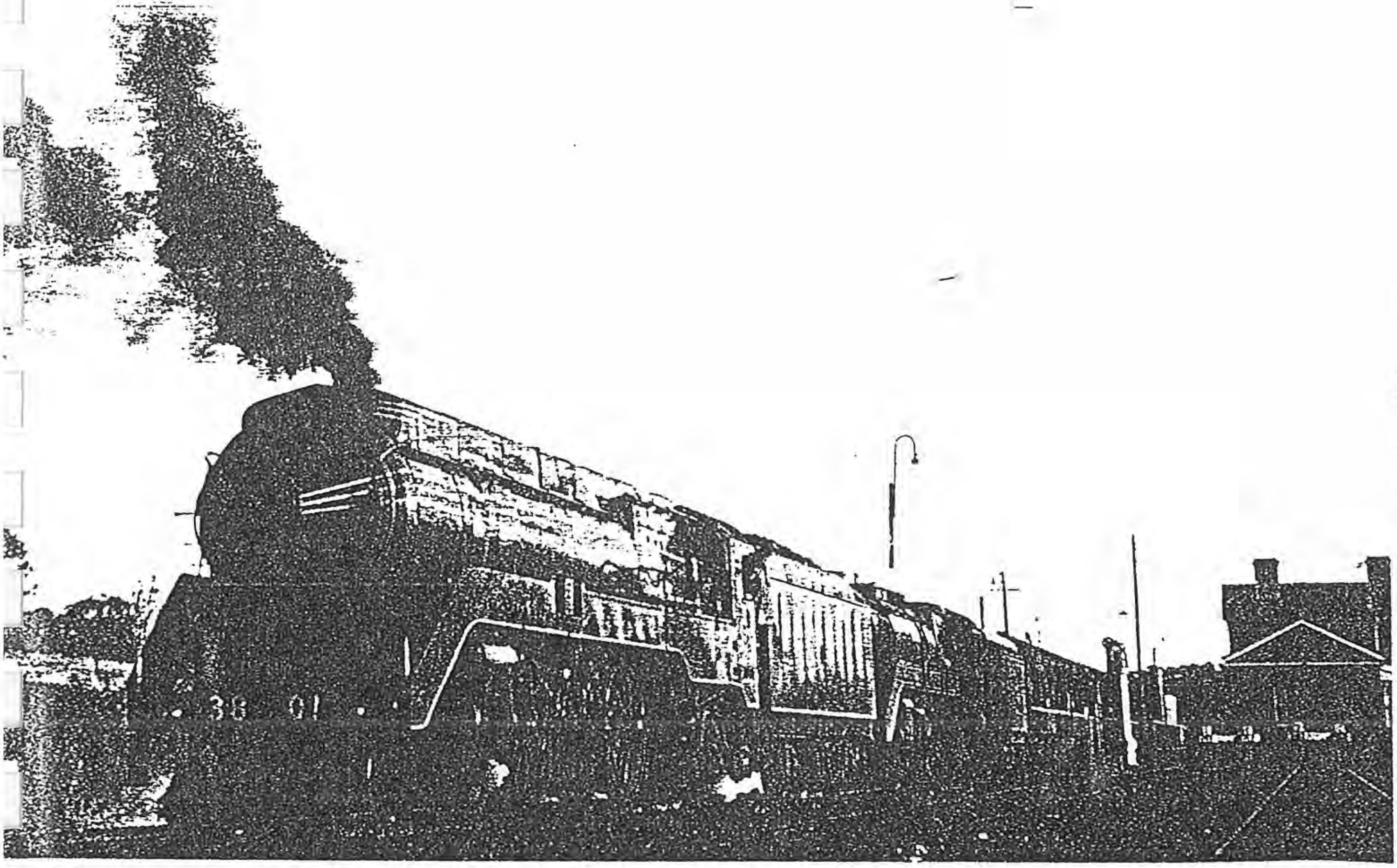

Alpha and Omega - the first and the last. Class leader 3801 and the final 38, 3830 pause at Wallerawang with a tour train in May 1964. Proceeds from this book will help restore 3830 and, perhaps, scenes such as this will again be possible.
Photo: Ray Love

BACK COVER
In the early years of its career 3801 hauled the major express trains of New South Wales but retired to lesser trains when diesel and electric locomotives stole the limelight. In the upper photo, an Illawarra line passenger is started out of Waterfall while below, a Goulburn-bound goods is urged through the Southern Highlands, the famous Pacific providing the tractive power for both trains.
Photos: Graeme Bedwin

The C38 Class 4-6-2 Type Locomotive

By Harold Young AMIE Aust
Journal of the Institution of Engineers, Australia
Vol 16, Oct-Nov 1944

The C.38 Class 4-6-2 Type Locomotive

In service on the New South Wales Government Railways.

BY HAROLD YOUNG.

(*Associate Member*).*

INTRODUCTION.

The heaviest passenger trains of 500 tons require, on the [N.]S.W. Railways, two 4-6-0 type locomotives of the C.36 class. [It] was considered that a Pacific locomotive, which is a 4-6-2 type, could be designed to give better locomotive proportions, [g]reater power with a relatively small increase in weight on the [dr]iving wheels, less destructive action upon the track and to [eli]minate double heading on all grades other than the 1-40 or steeper.

Therefore, the C.38 class locomotive, of the two-cylinder [si]mple Pacific type, was designed by the Mechanical Branch, [N.]S.W. Railways, and constructed by the Clyde Engineering Co. Ltd., Sydney, to Railway working drawings, specifications [a]nd inspection, and certain important components were completed [at] Eveleigh and supplied to the Company.

The first of a series of five was placed in service on 22nd January, 1943, and has performed to expectations.

GENERAL DIMENSIONS.

The general dimensions are given hereunder:—

[To]tal weight in working order, engine and tender ...	201 tons 4 cwt.
[W]eight on drivers in working order ...	67 tons 4 cwt.
Cylinder diameter and stroke ...	$21\frac{1}{2}$ in. × 26 in.
[H]eating surface, fire box and combustion chamber ...	225 sq. ft.
[Tu]bes and flues ...	2,362 sq. ft.
[Ar]ch tubes 3 in. O.D. gauge 7 BWG. 180 ...	27 sq. ft.
[S]uperheater ...	755 sq. ft.
TOTAL ...	3,369 sq. ft.
[G]rate area ...	47 sq. ft.
[B]oiler pressure ...	245 lb. per sq. in.
[V]alve type ...	12 in. piston with trick port.
[V]alve motion ...	Walschaerts.
[Fi]rebox ...	Wide Belpaire.
[N]umber of $2\frac{1}{4}$ in. tubes 11 B.W.G. ...	142.
[N]umber of $5\frac{1}{4}$ in. flues (superheater 8 B.W.G.)	36.
[L]ength between tube plates ...	17 ft. 9 in.

PROPORTIONS AND RATIOS.

The calculated tractive force is 36,200 pounds, with 85 per cent. of the boiler pressure (245 lb./sq. in.). This is equal to [1]72.8 pounds pull, per pound of mean effective pressure.

The ratio of weight to the calculated tractive effort is 4.15. The formula for rated tractive effort is—

$$\text{RTE} = \frac{d^2 \times 0.85\, P \times S}{D}$$

where d = cylinder diam., in inches.
P = boiler pressure, in lb. per sq. in.
S = cylinder stroke, in inches.
D = diam. of coupled wheels, in inches.

The rated or cylinder tractive effort depends on the diameter of the cylinders, the boiler pressure and the diameter of the driving wheels and is fairly correct for low speeds. At higher speeds, however, the rated tractive effort is limited by the boiler evaporation and is sometimes called the boiler tractive effort, which is a curve of hyperbolic shape. The proportions of the locomotive boiler and cylinders are therefore related to each other.

The idea of using cylinder horse power as a basis of boiler proportions was introduced by Mr. F. J. Cole, Consulting Engineer of the American Locomotive Co., and in his bulletin on Locomotive Ratios, he explains the boiler horse power as equal to the maximum evaporation of steam, in pounds per hour, divided by the amount of superheated steam required per cylinder horse power per hour, with a piston speed of 1,000 feet per minute.

Mr. Cole considered 20.8 lb. of steam, superheated 200° F. above boiler pressure temperature, as a suitable divisor, and a figure which provides sufficient steam for cylinders and auxiliary services.

The steam consumption per horse power depends on the boiler pressure and degree of superheat; the higher the boiler pressure and degrees of superheat, the greater will be the economy in steam consumption.

To maintain this economy, piston valves should have long travel and the steam ports and passages carefully proportioned and streamlined to prevent losses due to steam friction or wire drawing of steam.

It is assumed, having regard to all the above factors, that the steam consumption of 19 lb. per indicated horse power hour will be realised in service.

The maximum cylinder horse power, by using Cole's formula, is—

$$\text{h.p.} = 0.0229 \times P \times A = 2036$$

where P = boiler pressure, and A = area of cylinder.

∴ Estimated total pounds of steam per hour = 2036 × 19 = 38,684 lb.

The objective is to provide a boiler capable of supplying steam efficiently to meet the demands of the cylinders.

The C.38 boiler is estimated to produce 37,380 lb. of saturated steam per hour, and therefore should be capable of supplying 96 per cent. of the steam required for the cylinders. In figuring the boiler output it is assumed that 55 lb. of water can be evaporated per hour for each square foot of heating surface of the firebox, combustion chamber, and arch tubes, and 10 lb. of water for each square foot of heating surface of the tubes and flues.

The grate area is 47 sq. ft., and is of such dimensions that the rate of combustion at maximum horse power need not exceed 120 lb. of coal per sq. ft. of grate area per hour.

The C.38 is fired with Abermain coal (14,000 B.Th.U.), and it is considered the coal consumption would be approximately 2.8 lb. per horse power hour, or about 43 horse power per sq. ft. of grate area. Total h.p. for grate area would be 43 × 47 = 2021. The rate of coal consumption in service can be increased to give a higher horse power per square foot of grate area, when necessary, but tests have proved that such increase on the figure given is uneconomical in fuel consumption.

The combustion chamber and the firebox proper give a ratio of volume to grate area of 5.9.

The five arch tubes are disposed to secure safely the brick arch. The area between the brick arch and the crown of the firebox is 145 per cent. of the flue area, which is 883 sq. in. = 6.12 sq. ft.

The fire grate is the single unit design supported on carriers having air openings equal to 20 per cent. of the grate area. The grates are hand operated in sections, by a lever in the cab, for rocking and dumping the fire.

*This paper, No. 853, originated in the Sydney Division of The Institution, and was [p]resented before a General Meeting of the Mechanical Engineering Branch of the Division, [o]n 15th March, 1944.
The author is Chief Mechanical Engineer, Department of Railways, N.S.W.

The ashpan is of the hopper, self-emptying type. The hopper door is hand operated from the ground level and closed by gravity. Water flushing gear and damper doors are controlled from the cab. The air openings of the ashpan equal 16 per cent. of the grate area, and the air is evenly distributed under the grate. Experience has proved that this latter arrangement reduces firebox sheet trouble.

The automatic air operated butterfly type fire door with a foot pedal control is fitted to the firebox. This enables the fireman to open and close the door during firing operations, thus controlling entry of air to the firebox to an absolute minimum.

Steam is collected by a tangential steam dryer in the dome and conveyed in an 8 in. dia. steel tube to a multiple valve regulator on the saturated side of the superheater header, which is attached to the front tube plate of the boiler. The connecting joint between header and internal steam pipe is spherical, to allow for irregularities and to give a dependable steam joint. The 36 elements of the bifurcated type are connected to the header with flanges and high tensile steel bolts. Spherical shaped joints are used, and these seldom give trouble in service. This type of superheater has 755 sq. ft. of heating surface and delivers superheated steam to the cylinders at approximately 650° F. In ordinary working the temperature would vary, but at a conservative estimate the volume of saturated steam would be increased by 25 to 30 per cent., and as a certain amount of heat is absorbed in superheating the steam, the fuel saving would be about 20 to 25 per cent.

An interesting and original feature in the all-steel boiler which is of the Belpaire design, is the connection between the barrel and firebox casing. The difficulty of connecting a Belpair firebox with an inclined throat plate to the barrel of a boiler c the type usual with a combustion chamber, was overcome b fitting what we now call a Belpaire ring, 1 ft. $3\frac{7}{8}$ in. in lengt This ring is flanged from a flat plate and has not any weakenin longitudinal seam. It is shaped at the top similar to a co ventional Belpaire throat plate, but is cylindrical below the boil centre line.

The stays are manufactured from steel of high tensile qualit thus saving weight and aiding flexibility. All stays are of t rigid type, with the exception of wall stays in the top three ro and a few in the "breakage" zones. The longitudinal an transverse stays are screwed through the plate without back nut This method will enable any stay to be withdrawn without di turbing others in the vicinity.

The barrel of boiler is conical in shape and consists of tw courses of alloy steel plate. The diameter at the Belpaire ste ring is 6 ft. $6\frac{1}{8}$ in. and 5 ft. 9 in. at the front tube plate angle ir ring, the thickness of the plates being $\frac{11}{16}$ in. and $\frac{5}{8}$ in., respectivel

The superheater flues are grouped around the vertical cent line of the tube plate, leaving sufficient space for rows of small tubes at the sides or wings. This permits the tube plates fre movement for expansion and contraction of the tubes, and giv longer life to the tube plates.

The boiler front tube plate is riveted to the smokebox sh Two expansion brackets, spaced laterally 3 ft. 0 in. apart, a attached to the front foundation bar, and these transfer part the weight of the boiler to the locomotive bed pads. Phosph

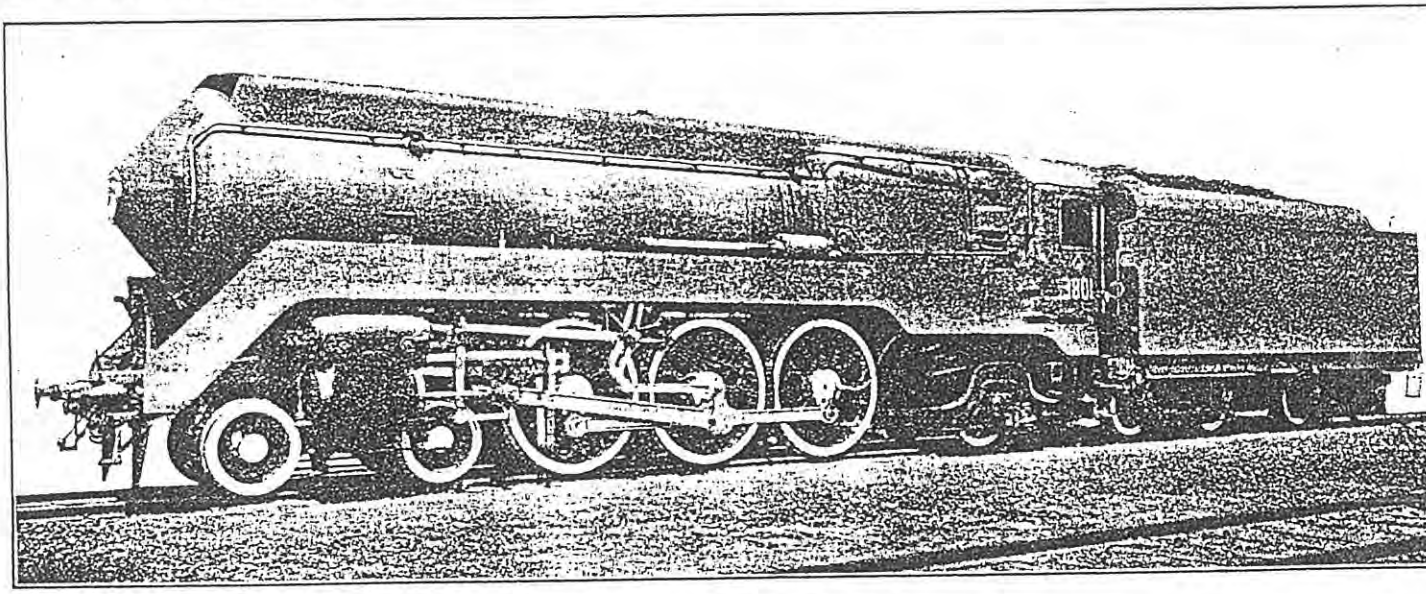

Fig. 1.—General View of the C.38 Class Locomotive.

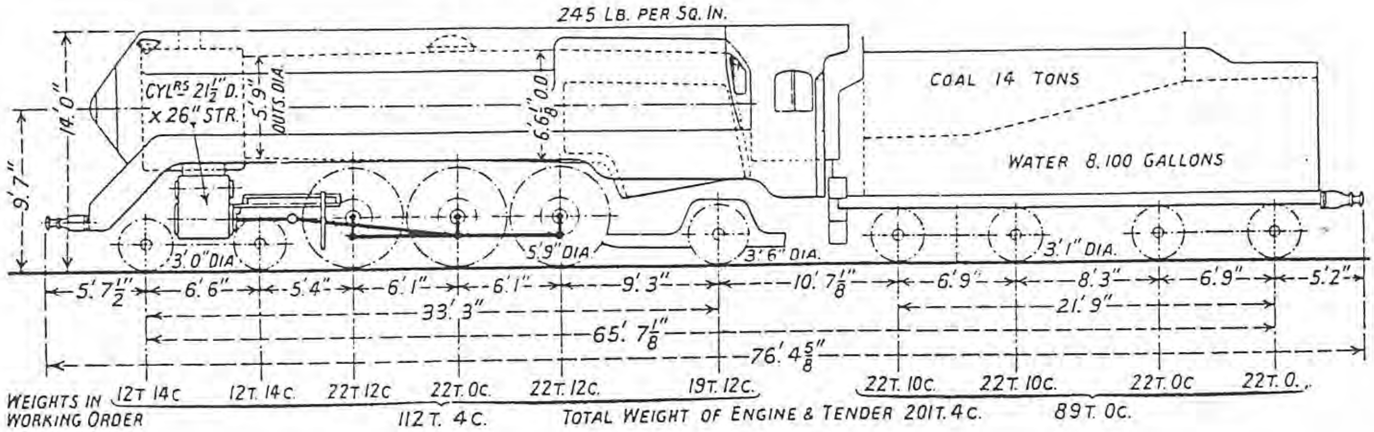

Fig. 2.—Diagram giving Principal Dimensions and Axle Loads.

—Reproduced from the *Railway Gazette* (Aug. 11, 19

ronze liners between the brackets and pads are fitted to keep the iler in the correct horizontal position, and the area is such that e bracket can slide freely as the boiler extends or contracts ongitudinally or laterally, without appreciable wear between hoppings.

The boiler barrel is connected to the locomotive bed near e circumferential seam, by means of a $\frac{3}{8}$ in. thick plate which is bolted to a steel casting bracket on bed and to an angle iron which is riveted to the barrel. A reinforcing plate between the igle iron and the barrel plate is securely riveted to the barrel.

At the rear of the firebox the foundation bar is connected o the bed by three $\frac{1}{4}$ in. plates and bolts.

Every care was taken to secure the boiler to the frame and the same time to allow controlled movement.

The boiler has a factor of safety of 5 and is protected by hree $3\frac{1}{2}$ in. dia. Ashton Muffled Pop Safety Valves, type F.C.10, nd four fusible plugs, tin filled, are fitted on the crown sheet of e firebox.

Feed water is supplied by two 11 mm. live steam injectors ositioned below the footplate on the right and left sides. Each njector is capable of delivering 3,400 gallons of water per hour. hree blow-off cocks are fitted, one on each side of the firebox, d the third on the first ring of the boiler barrel.

The smokebox is 6 ft. 11 in. inside diameter, and 7 ft. 0 in. ong, and is strongly reinforced where it is securely bolted to the ddle of the locomotive bed or frame.

It is proportioned and equipped not only to expel all ashes nd sparks from the boiler flues and tubes through the chimney n a condition free from fire hazard, but also to maintain a draft fficient for all rates of firing up to 120 lb. per sq. ft. of grate ea per hour.

The draft normally measures from 8 to 10 in. of water at he back of the diaphragm, and in practice induces sufficient air r efficient combustion in the firebox. Each pound of coal nsumed requires at least 13 pounds of air, otherwise the per-entage of smoke increases and the boiler efficiency decreases.

The draft is brought about by positioning the cylinders exhaust steam nozzle concentric with the chimney. The chimney is in three sections, the lower section has a parallel base of 18 in. diameter and is equal in area to 29 per cent. of the net flue and tube gas area, and flared, while the other two sections have a taper of one inch in fifteen upwards.

At normal cylinder back pressures of 5 to 7 lb. per sq. in., the exhaust steam leaves the nozzle when fitted with spreaders, at an angle of 6 degrees, so that it is necessary to locate the nozzle in such a manner that the exhaust steam contacts the upper section 12 in. below the top of the chimney.

The nozzle is a bush of the usual circular shape and is held in position by an outer flanged bush which is bolted to the blast pipe. Attached to this outer bush are the spreaders and perforated steam pipe blower. This arrangement facilitates adjustment as regards the suitable area of nozzle and the relative position of spreaders.

The spark arrester with $\frac{1}{4}$ in. mesh has a net area of 124 per cent. of the gas areas, and under the draft sheet the area is 90 per cent. A damper door is fitted between the diaphragm and the tube plate, and is automatically controlled by the regulator valve allowing steam to enter a vertical steam cylinder on the left hand side of the smokebox.

The damper door, when in the closed position, provides for sufficient opening between the edge of the door and diaphragm to allow the draft partly to function and maintain steam when the locomotive is coasting or drifting with open steam pilot valve.

The pilot valve permits sufficient steam to destroy vacuum developing in the cylinders and exhaust pipe while locomotive is coasting, and reduces effectively the tendency of ashes to reach the main piston valves.

The drifting gauge in the cab enables the driver to adjust the pilot valve to permit sufficient steam to the cylinder to eliminate vacuum at all piston speeds.

The smokebox door is a flanged plate 5 ft. 0 in. dia., $\frac{1}{2}$ in. thick, and fits into a V-grooved ring—the door is secured by a

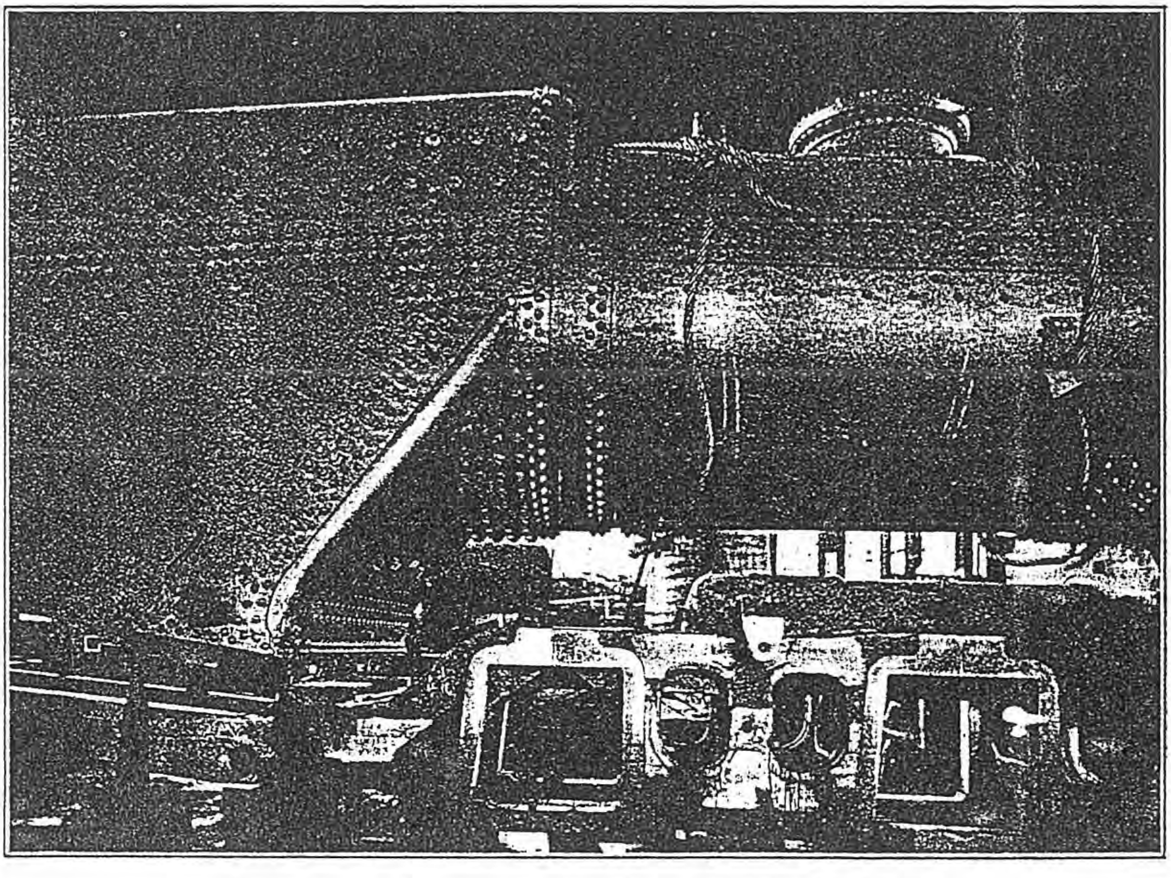

Fig. 3.—Showing Firebox-Boiler Barrel Connection by One-Piece Pressing.

...ss bar, dart screw, and lockwheel. This ensures an air-tight ...int, and the door gives trouble-free service.

Immediately above the multiple valve regulator which is ...gral with the superheater header, an opening with cover ...e held in position with set screws is made in the smokebox ...ell. This gives easy access to the six valves for adjustment and ...intenance.

The regulator lever is located in the cab convenient to the ...iver. The rod from the cab to the smokebox is taken through ...e handrail, and the movement of the regulator lever is trans-...ted by a straight lever, with fulcrum on its centre, into a push ... pull movement on the rod. This allows for expansion and ...ntraction of the boiler without displacing position of the valves. ...ll the operating gear is outside of the boiler.

The first movement of the cab lever operates the horizontal ...n shaft in the header, which opens the easing valve and permits ...team to enter the balancing chamber, and so equalises pressure ...nder balancing pistons equal to that in the header. Further ...vement of the regulator cab lever opens the pilot valve and ...n the main valves in the order of 1, 3, 2, 4; closing takes ...lace in reverse order, the valve which opens last being first, ...nd each valve successively seating until pilot and easing valves ... the last to close.

The opening of the regulator releases saturated steam to the ...6 bifurcated elements made from 1¼ in. internal diameter tubing, ...nd the steam which is superheated in the process returns to the ...perheater compartment of the header and from there is con-...ved by two 6½ in. internal diameter steam pipes to the cylinders.

A tabulated statement of areas and proportions of components ...rough which the steam is conveyed from boiler to blast pipe, ... given hereunder.—

...e and area through internal steam pipe—8 in. internal dia.	=	50.3 sq. in.
...ize and area through regulator valves—8 in. dia....	=	50.3 sq. in.
...e and area through superheater elements—36 at 1¼ in. dia....	=	44.17 sq. in.
...ize and area through steam pipes between header and cylinder—6½ in. internal dia.	=	33.2 sq. in.
...ton area—21½ in. dia.	=	363 sq. in.
...ept volume of piston—26 in. stroke ...	=	9438 cub. in.
...tual area through steam ports in piston valve liner	=	56 sq. in.
...ffective area through steam ports	=	49 sq. in. (= 13.5 per cent. piston area).
...ea of steam passage between piston valve and cylinder	=	48.2 sq. in. (= 13.3 per cent. of piston area, or piston area to steam passage area = 7.5 : 1).
...learance volume	=	1274 cu. in. (= 13.5 per cent. of swept volume).
Actual area through exhaust ports in piston valve liner	=	118.6 sq. in.
Effective area through exhaust ports in piston valve liner	=	63.6 sq. in. (= 17.5 per cent. of piston area).
Area of exhaust passage (at blast pipe) ...	=	55 sq. in. (= 15.1 per cent. of piston area).
Area through nozzle—7½ in. dia.	=	44.2 sq. in.

Note.—A ratio of 7.5 to 1 for piston area to steam port area, has been achieved, and this is a considerable improvement when compared with the usual 10 : 1.

Locomotive Boiler Efficiencies :

Assuming total heat supplied by coal in fire-box	=	100%.
Then, overall boiler efficiency with rates of firing of 120 to 30 lb. per hour per sq. ft. of grate area	=	55% to 78%.
Heat liberated by furnace	=	75% to 96%.
Heat loss by furnace	=	25% to 4%.
Heating surface efficiency	=	88% to 96%.
Firebox temperature	=	1900 to 2200° F.
Smokebox temperature	=	500 to 600° F.
Air supply per pound of coal consumed ...	=	15 lb.

Velocity of gases in system range up to 200 miles per hour.

Arch tube: Each arch tube adds 1% to boiler efficiency.
Brick arch adds 10% to boiler efficiency (varies with rate of firing).
Ashpan draft, in inches ... 0.3 (varies with rate of firing).
Smokebox draft, in inches ... 10 (varies with rate of firing).
Actual ratio of steam space to water space = 33.1%.
Actual ratio of steam space to total volume = 24.9%.

Table I, showing dimensions and proportions of modern locomotive boilers, is taken from Mr. E. C. Poultney's paper on "Proportions of Locomotive Boilers," as published in *The Railway Gazette*, April 9, 1943.

For comparative purposes the writer has taken the liberty of adding to the table, the dimensions and proportions of the N.S.W. D.57 and C.38 locomotives. The C.38 was designed in 1938, five years before Mr. Poultney's paper was published, and it will be seen that the C.38 boiler proportions compare quite favourably with a wide range of boiler designs on a number of important railways.

VALVE GEAR.

The Walschaert valve gear operates two 12 in. dia. inside admission piston valves for the distribution of steam to the cylinders. The maximum travel of the valve assembly is 6½ in.

The design of gear follows the usual practice. Attention is drawn, however, to the large reversing link which allows a die block travel of 18¾ in., measured from the full forward to the full backward position. This unusually large travel permits the exploitation of the air powered precision reversing gear, and enables the locomotive driver to select the precise cylinder steam cut-off best suited for the load, grade, speed, and boiler capacity.

FORWARD

	VALVE TRAVEL	LEAD FP	LEAD BP	PORT OPENING FP	PORT OPENING TP	PORT OPENING BP	PORT OPENING TP	CUT-OFF % F	CUT-OFF % B.	DIFF. %	RELEASE % F	RELEASE % B	DIFF. %	Angle of crank of release F	Angle of crank of release B	DIFF.	SLIP OF BLOCK
FULL	6 9/16"	3/64"	3/64"	1 3/4"	—	*2 1/16"	—	83 1/4	79	4 1/4	94 1/2	92 1/4	2 1/4	151 1/4°	149 1/2°	1 3/4°	9/32"
	4 15/16"	-	-	1"	1/2"	1 1/16"	5/16"	70	65 1/4	4 3/4	89 3/4	86 1/4	3 1/2	140 1/2°	138 1/2°	2°	7/16"
	3 31/32"	-	-	9/16"	1/2"	21/32"	19/32"	53 3/4	50 1/2	3 1/4	83 1/4	79	4 1/4	129°	127°	2°	7/16"
	3 21/64"	-	-	1/4"	3/16"	21/64"	17/64"	32	33 3/4	1 3/4	74	70 1/2	3 1/2	116°	117°	1°	
	3 11/64"	-	-	3/16"	1/8"	15/64"	11/64"	23 1/4	26	2 3/4	69 1/4	66 1/2	2 3/4	109 1/2°	112°	2 1/2°	
MID	2 27/32"	-	-	3/64"	—	3/64"	—	2 1/2	3	1/2	43 1/2	45	1 1/2	79 1/2°	87°	7 1/2°	

BACKWARD

	VALVE TRAVEL	LEAD FP	LEAD BP	PORT OPENING FP	PORT OPENING TP	PORT OPENING BP	PORT OPENING TP	CUT-OFF % F	CUT-OFF % B.	DIFF. %	RELEASE % F	RELEASE % B	DIFF. %	Angle of crank of release F	Angle of crank of release B	DIFF.	SLIP OF BLOCK
FULL	6 1/4"	1/16"	3/64"	1 5/8"	—	1 7/8"	—	83 1/2	78 1/2	5	93 3/4	91 3/4	2	150 1/2°	148 1/2°	2°	1"
	4 57/64"	3/64"	1/16"	15/16"	9/16"	1 5/64"	17/64"	71	68 3/4	2 1/4	89 3/4	87 1/2	2 1/4	141 1/2°	142°	1/2°	27/32"
	3 31/32"	3/64"	3/64"	1/2"	7/16"	23/32"	21/32"	50 1/4	55	4 3/4	83	81	2	129 1/2°	131°	1 1/2°	5/8"
	3 11/32"	1/16"	3/64"	1/4"	3/16"	3/8"	5/16"	27 1/4	36 1/4	9	72 1/4	72	1/4	114°	119 1/2°	5 1/2°	
	3 7/32"	1/16"	3/64"	3/16"	1/8"	9/32"	7/32"	22 1/2	31 1/4	8 3/4	69 1/4	69 1/2	1/4	110°	116°	6°	
MID		3/64"	3/64"	3/64"	—	3/64"	—	2 1/2	2 3/4	1/4	42 1/2	44 1/4	2	78 1/2°	87°	8 1/2°	

Clearance of bottom of link 1 1/16"

* Maximum width of port 2"

Clearance at top of link 1 1/8

Steam lap of valve 1 3/8"
Negative exhaust lap of valve 3/16"
Lead of valve (designed) 1/16"

Fig. 4.—Valve Events for C.38 Class Engines.
F.P. = front port; B.P. = back port; T.P. = trick port.

The piston valves are unique in design detail and are pro-·ided with auxiliary steam ports.

There are three cast iron L-shaped packing rings in each ·ead. The admission and exhaust rings are spaced 3 3/16 in. overall, and while the middle ring is positioned to control the ·unctioning of the auxiliary steam ports to prevent excessive re-admission, it also serves as an additional safeguard against ·igh pressure steam reaching the exhaust passages.

It should be mentioned that the auxiliary ports are con-·ected by a 5 in. diameter steam passage between piston valve ·eads. These ports receive steam from the steam chest at one ·nd and deliver steam to the cylinder at the other end as required. The piston valve assembly has a crosshead attached to each end ·f the valve spindle which contacts adjustable slides bolted to the ·xhaust steam covers. This enables the junk and lantern rings ·o remain clear of the valve liners, and permits the L-shaped ·acking rings to function properly.

The valve events are given mainly to show the advantage ·ained in having auxiliary steam ports.

Reversing Gear.

The precision reversing gear, which operates the main valve ·ear, is an ingenious mechanism. It consists of a cylinder 2 ft. ·ong by 10 in. diameter to which is attached a slide valve chamber · the rear.

The trunk piston head is displaced to any cut-off position by a left hand threaded shaft equal in length to the cylinder. The shaft is extended rearwards to the slide valve chamber. To this extension a lever attachment, which actuates a slide valve, is securely bolted. When the slide valve is in central position air ports are open to both ends of the cylinder. To alter position from mid gear to full forward, the driver turns the operating hand wheel in cab clockwise until the indicator shows full forward. This movement withdraws the piston left hand screw from piston head, thus displacing the slide valve sufficiently to open front end cylinder port to exhaust. The rear port is open to air pressure which follows piston to full forward position. The slide valve automatically takes its central position and both ports are now open to air pressure. To reduce the cut-off, the driver revolves the hand wheel anti-clockwise until the indicator shows cut-off required. This action makes the piston shaft enter piston head, and consequently moves the slide valve from central position forward, and exhausts the air in rear of the cylinder. The front port is open to air pressure which follows piston to cut-off required. The slide valve automatically again takes up its central position.

The connection between the hand wheel and indicator in cab to reversing cylinder and valve, is a tubular shaft with two universal joints and one sliding splined joint which takes care of the expansion and contraction of the boiler and the turning movement. The connection between the valve motion weigh shaft lever and the end of the trunk piston, is a reach rod with pin

TABLE I.

Dimensions and Proportions of Modern Locomotive Boilers.

Railway	L.M.S.R.	L.N.E.R.	G.W.R.	S.R.	N.Y.C.	N.Y.C.	P.R.R.	P.R.R.	N.S.W.	N.S.W.
Type	4-6-2	4-6-2	4-6-0	4-6-2	4-6-4	4-6-4	4-6-2	4-8-2	4-8-2	4-6-2
Diameter of coupled wheels, in.	81	80	78	74	79	79	80	72	60	69
Rated tractive force (R.T.F.)	40,000	35,455	40,300	37,500	43,440	42,360	44,460	64,550	56,000	36,200
Working steam pressure, lb. per sq. in.	250	250	250	280	275	225	205	250	200	245
Boiler diameter, outside, front, in.	68⅝	69⅞	66¼	69⅞	80⅝‡	82 7/16‡	76⅜‡	82¼‡	73½	69
Tubes and flues, length between tube plts.	19'-3"	17'-11¾"	16'-5⅜"	17'-0"	19'-0"†	20'-6"†	19'-0"	19'-0"	20'-0¾"	17'-9"
Tubes, No. and diameter outs., in.	129—2⅜	121—2¼	171—2¼	124—2¼	59—2¼	37—2¼	237—2¼	120—2¼	165—2¼	142—2¼
Flues, No. and diameter outs., in.	40—5⅛	43—5¼	16—5⅛	40—5¼	183—3½	201—3½	40—5½	170—3½	40—5½	36—5¼
...ating Surfaces, sq. ft.—										
Firebox	230.5	231.2	193.5	220	323	244	277.8	370	259	225
Arch Tubes	—	—	—	—	37	37	29.0	29	37	27
Syphons	—	—	—	55	—	—	—	—	—	—
Total (F.B.H.S.)	230.5	231.2	193.5	275	360	281	306.8	399	296	252
Tubes and flues (T.F.H.S.)	2,577.0	2,345.0	2,007.5	2,175.9	3,827	4,203	3,734.4	4,303	3,094	2,362
Total (Evap. H.S.)	2,807.5	2,576.3	2,201.0	2,450.9	4,187	4,484	4,041.2	4,702	3,390	2,614
Superheater (S.H.S.)	856.0	748.9	313.0	822.0	1,745	1,951	940.0	1,630	773	755
Total (Comb. H.S.)	3,663.5	3,325.2	2,514.0	3,272.9	5,932	6,435	4,981.2	6,332	4,163	3,369
Grate area, sq. ft. (G.A.)	50.0	41.25	34.3	48.5	82	81.5	69.9	69.9	65	47
Firebox volume, cu. ft. (F.B.V.)	315.47	274.0	206.22	300	519	428	427	494	385	277
Free gas area through boiler, sq. ft. (F.G.A.)	6.89	6.46	4.47*	6.26*	8.91	9.67	9.10	9.71	7.5	6.12
...roportions—										
R.T.F./G.A.	800	858	1,210	774	530	520	636	924	862	770
F.B.H.S./G.A.	4.6	5.6	5.62	5.66	4.38	3.44	4.4	5.71	4.55	5.36
F.B.V./G.A.	6.3	6.63	6.07	6.19	6.32	5.25	6.1	7.07	5.92	5.9
F.G.A./G.A. × 100	13.7	15.6	13.1	12.9	10.86	11.85	13	13.9	11.53	13.0
T.F.H.S./F.B.H.S.	11.15	10.13	10.7	7.9	10.61	14.95	12.15	10.78	10.45	9.38
Evap. H.S./G.A.	56.2	62.3	58.4	50.5	51.0	55.0	57.7	67.3	52.25	55.65
S.H.S./G.A.	17.05	18.1	9.13	16.9	21.2	24.0	13.5	23.3	11.9	16.05
S.H.S./Comb. H.S. × 100	23.15	22.4	12.45	25.2	29.4	30.2	18.90	25.7	18.55	22.4
Comb. H.S./G.A.	73.4	80.6	73.3	67.5	72.2	78.9	71.3	90.5	64.00	71.7
Superheater type	A	A	A	A	E	E	A	E	A	A and Bif.
Feed water heater	Exh. inj.	Exh. inj.	—	Exh. inj.	F.W.H.	F.W.H.	—	F.W.H.	—	—

*Area at firebox tube plate. †Length over tube plates. ‡Diameter inside.

joints. The rod is adjusted to the correct length when boiler is under steam.

The cylinder threaded shaft is 1½ in. dia., triple Acme thread 3 threads per inch—1 in. lead left hand, and the screw in cab is 1½ in. triple thread—6 threads per inch—½ in. lead—so that the indicator travels half the distance of the piston.

Connecting Rod Feature.

The normal practice for connecting rod small end bearings is to provide a gunmetal bush, pressed hydraulically into the connecting rod. The gudgeon pin secures the connecting rod to the crosshead and provides a journal bearing area of such diameter and length that the pressure per square inch on the projected area falls within 4,000 to 5,000 lb. per sq. in.

The big end of the connecting rod is fitted with a revolving bush having a diameter and length to give a pressure of about 1,700 lb. per sq. in.

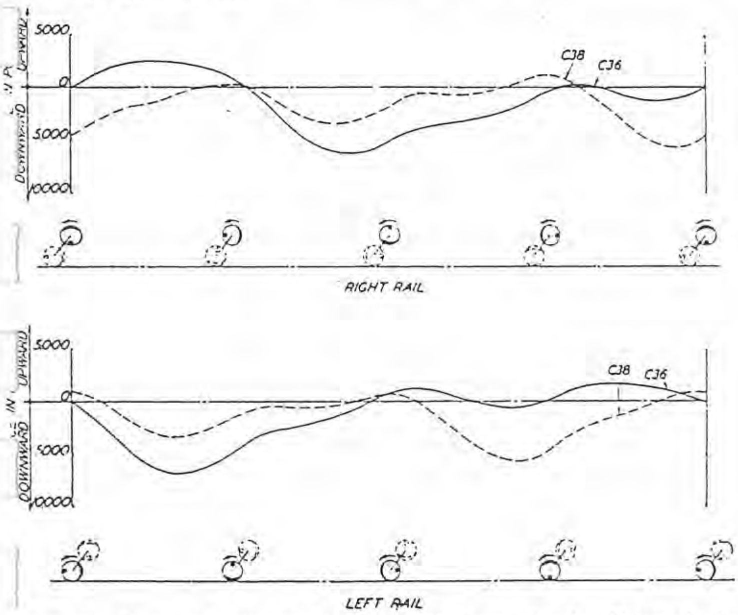

Fig. 5.—Dynamic Rail Load Variation at 70 m.p.h., for Classes C.36 and C.38 Engines.

Reasonably good results in service are obtained from this practice. There is evidence, however, that the angular displacement of the crank pin in operation imparts a tortional movement in the connecting rod which twists the crosshead, causing occasional loose gudgeon pins, broken slide bar bolts and brackets, and also slide bar wear.

To overcome these maintenance problems, a 6 in. dia. spherical bearing is introduced between the gudgeon pin and the split gunmetal bush in the connecting rod.

The clearance between the bearing and the bush is 6/1000 of an inch, after the bush with bearing has been hydraulically pressed into small end of connecting rod. The outside diameter of the bush is 7½ in. The gudgeon pin is fitted with a key which enters the keyway in the spherical bush and secures it in position.

The bearing is lubricated with a light grease, and is serviced every 400 miles.

Locomotive Balancing.

Where speeds in miles per hour are required which are numerically equal to the wheel diameter in inches, the designer is required to balance the coupled wheels, otherwise the hammer blow, or dynamic augment, would be of such magnitude as would cripple rails, damage bridge structures, and even cause derailment

Considering the dynamics of the driving mechanism of the locomotive, we have, on each side of the locomotive, masses that reciprocate, masses that revolve, and masses that partly reciprocate and partly revolve. These masses, when the locomotive is in motion, set up disturbing forces and couples, and these become increasingly severe as the speed of the locomotive is increased, and if nothing were done to minimise them, would damage both the locomotive and its track when high speeds were attempted.

To permit operation at high speeds, therefore, it becomes necessary to reduce the disturbing forces and couples. This is done by means of masses so disposed in each wheel that they not only balance the forces in that particular wheel, but they also balance in it the components of the forces in the wheel on the other end of the axle. In other words they would be "cross-balanced."

Those forces and couples, however, set up by the reciprocating and partly reciprocating masses, can only be eliminated, or reduced, at the expense of introducing equal forces and couples acting on the track and under line structures, for, in a locomotive this

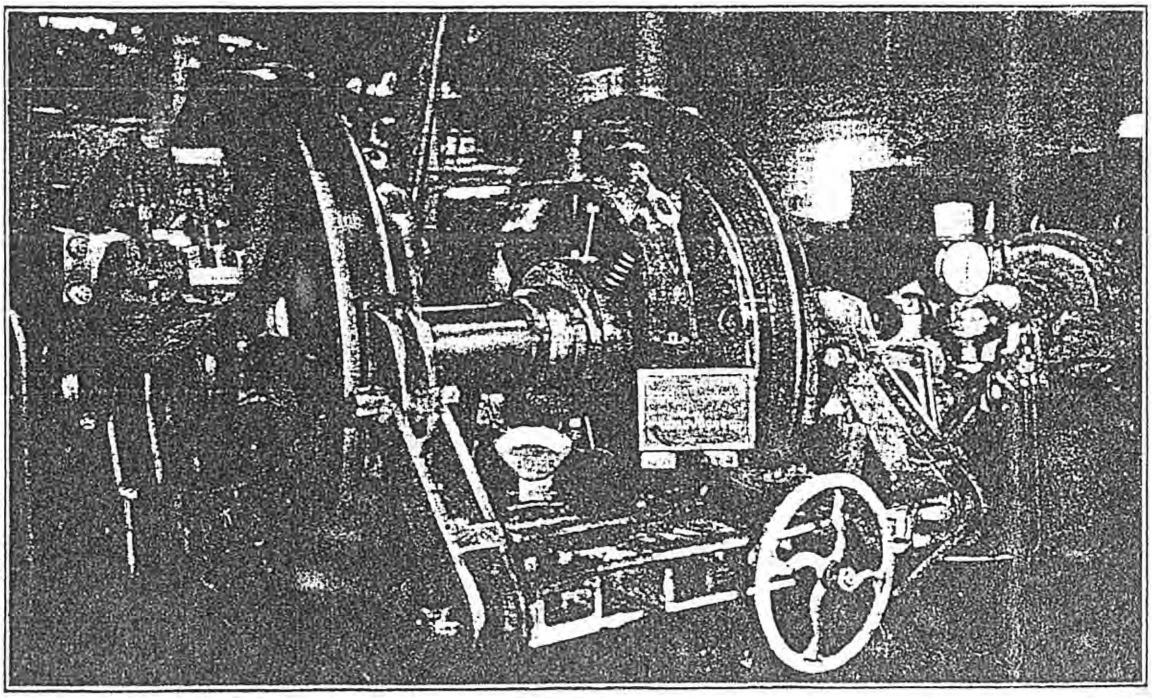

Fig. 6.—Showing Main Driving Wheels in Dynamic Balancing Machine.
Each bearing is fitted with three thermo-couples to record temperature.

·alance of the reciprocating masses is brought about by the aid of volving weights. Since only that component of the revolving eight resolved into the plane of reciprocation is effective for balancing the reciprocating masses, this same component at ·nce introduces an equal force and couple acting at right angles the line of stroke, and in a vertical direction. This force and ouple, acting on the track, cause a variation in pressure between the wheels and the rails. In order to keep this variation within imits it is the practice to balance only a proportion, varying ccording to circumstances.

Locomotive counterbalancing is, then, a compromise between the requirements of two of the engineering branches of ny railway system, viz., the Civil and the Mechanical Branches. enerally, the best compromise is to distribute the desired reprocating balance between the coupled driving wheels so that the locomotive has the minimum effect upon the track and the nbalanced forces have the minimum effect upon the locomotive. his distribution may, but need not, be effected equally amongst l the coupled driving wheels, or one pair of wheels may be made to carry more than another. Consideration of this charcter, together with the correct amount of reciprocating balance adopt for the locomotives of the New South Wales Railways, now receiving intense study in these railways.

Following a revision of the balancing of the C.36 class 4-6-0 ype locomotive, it was found that, by reducing the proportion f reciprocating weights balanced from 51 to 15 per cent., which, 1 effect, reduced the dynamic augment from 7 tons to 1 ton on the driving axle at 69 miles per hour, while the engine rode vith improved steadiness and indicated no tendency to nosing, here was also an improvement in the trailing or cab end of the comotive.

From this test it was considered that if the C.36 had a trailing ruck it might be possible to eliminate balancing of the reciprocatg weights altogether.

The C.38 is provided with a trailing truck and, of course, a four-wheeled bogie at the front end, which are both fitted with onstant resistance devices giving a lateral control of 20 per cent. er axle, i.e., 20 per cent. of the axle load. It was decided carelly to balance C.3801 for revolving weight only, and arrange the design of the balance weight in the coupled wheel centres so hat counter weights could be conveniently applied if this became ecessary or desirable, to improve the stability of the locomotive 1 running.

Locomotive 3801 has been in service since January, 1943, nd has completed over 80,000 miles at speeds up to 75 miles er hour, and as it is regarded by enginemen and others, to be oted for smooth riding characteristics, all locomotives of this classification will be placed in commission without reciprocating ounter weights.

The graph in Fig. 5 is self-explanatory. It shows the effect on the rail due to combined dynamic augment and piston thrust for C.36, and piston thrust for C.38, also the indication that when piston thrust gets too high, the need for multi-cylinder arrangements should be considered.

When, therefore, we add the driving wheel axle loads due to the static load + dynamic augment + piston thrust, we have the following.—

1926 design C.36 : 20 + 7 + 2 = 29 tons.
1939 design C.36 : 21 + 1 + 2 = 24 tons.
1938 design C.38 : 22 + 0 + 2.4 = 24.4 tons.

Locomotive Bed.

The locomotive bed or frame is a one piece steel casting and incorporates the cylinders, steam chest, smoke box saddle, main air reservoir and many brackets for supporting the valve motions, brake hangers, compensating spring beams, Westinghouse brake air pump, boiler supports, and slide bar brackets, etc.

The steel is of low carbon quality and suitable for welding, so that repairs due to mishaps in service and such like can be readily and efficiently effected.

The total weight of the steel casting is 18.7 tons. The estimated weight of a plate or bar frame with suitable independent accessories, approximates an additional 3.6 tons. This saving in weight is important, as it permits the design of a larger and more efficient boiler, having regard to the permissible loads on driving and bogie wheels.

The D.57 4-8-2 locomotive beds have been in service since 1929 and the experience gained since then proves that maintenance costs are negligible compared with fabricated frameplates.

Axlebox Bearings.

The problem of hot bearing boxes on locomotives and tenders is constantly under review, and much thought and effort has been given in recent years to increase the miles run per hot box; nevertheless, the serviceability of a locomotive frequently depends upon the condition of the bearings, and any improvement in this regard is of major importance to the operating staff.

An analysis of locomotive hot boxes over an extended period, and the damage incurred to associated parts, indicate the limitations of the normal axlebox design, whether lubricated with grease or oil.

The self-aligning spherical roller bearing appeared to be the answer to the problem and it was decided to apply this type of bearing to all the locomotives and tender axleboxes.

The outside axlebox self-aligning roller bearing is secured to the axle by a tapered split withdrawal sleeve and lock nut, care

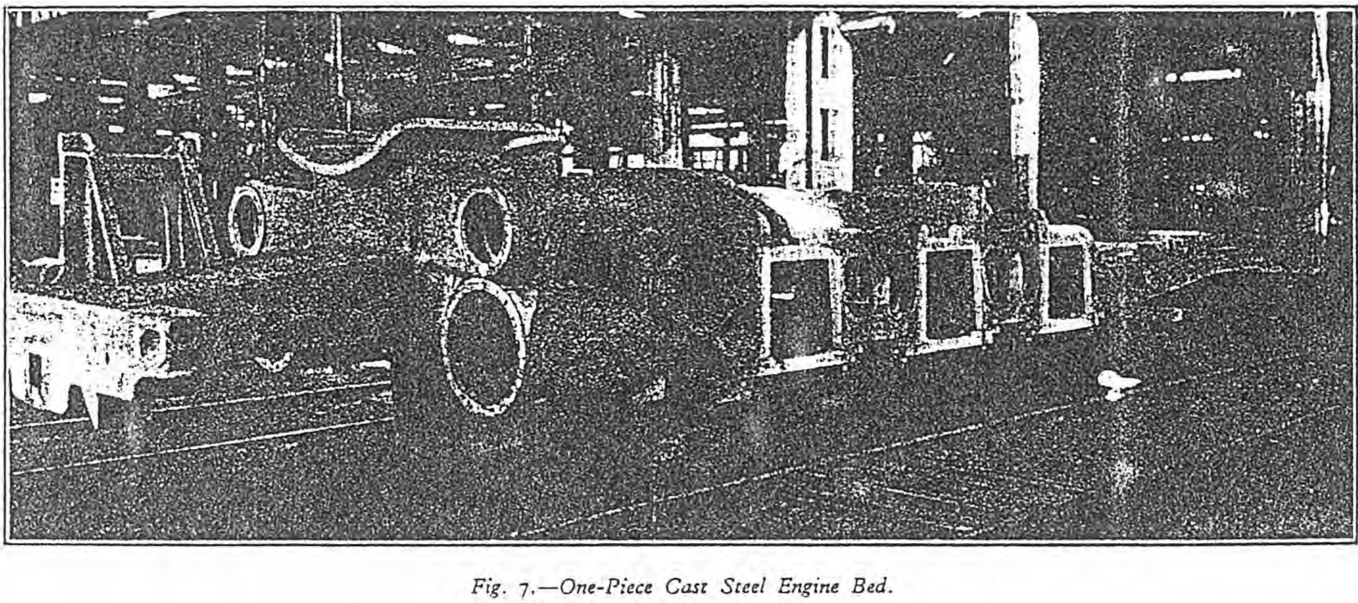

Fig. 7.—One-Piece Cast Steel Engine Bed.

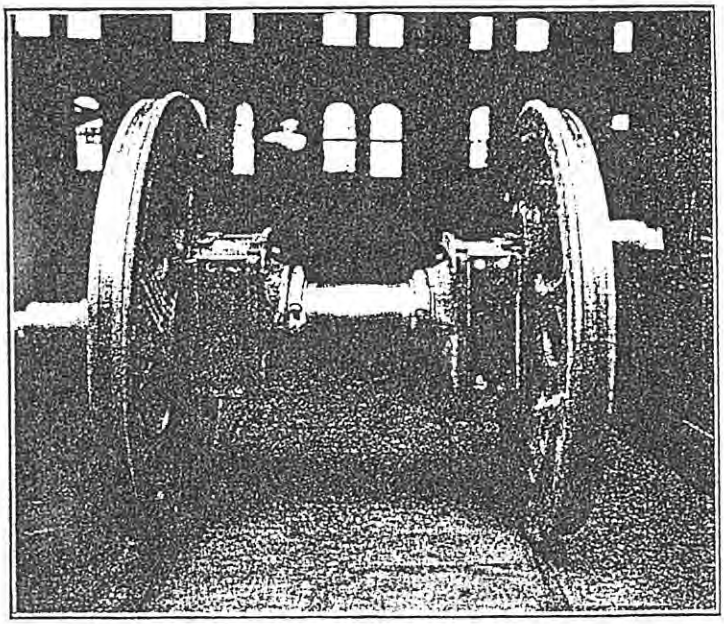

Fig. 8.—Dynamically Balanced Main Driving Wheels with S.K.F. Self-Aligning Roller Bearing Axleboxes.

being taken to maintain sufficient clearance between the rollers and the inner race surface. The outside axlebox steel casting housing is in one piece, and is a push fit on the outer race. Seals, manganese steel liners, and inspection cover, complete the assembly. By removing the end covers of axleboxes the wheels with axle can be put into the lathe for tyre attention.

The inside axlebox self-aligning roller bearings for coupled and leading bogie wheel axles, are normally mounted and secured in position by a pressed fit on the axle before the wheel centres are hydraulically pressed into position. This practice was not approved in view of the railway policy of magnetically testing and inspecting all axles for failure while the locomotive is undergoing periodic heavy repairs. Designs were prepared and approved for the bearings to be mounted on withdrawal tapered sleeves similar in many respects to outside bearings. It is required, however, for the bearings, seals, and nuts, to be threaded on to the axle before the wheels are pressed on to the axle.

The diameter of the driving axle at the wheel seat is $10\frac{7}{8}$ in., and at the bearing $10\frac{1}{2}$ in., and to allow for axle renewal the inside diameter of bearing race was supplied 11 in.

The axlebox steel casting housing is in halves, and bolted together so that the outer race is held securely to the housing.

The self-aligning feature provides for an axial movement of two degrees, or $3\frac{1}{2}$ in. between bearings. This permits the axleboxes to move in a vertical plane between parallel guides and eliminates tortional forces on the spring saddles, bearing springs and compensating gear. The easy removal of the bearings allows for the inspection and magnetic testing of axles in accordance with the established practice of the N.S.W. Railways.

Spring Gear.

Considerable care was taken in designing the compensating and spring gear to ensure smooth riding at high speeds and track loading limitations. The coupled wheels and trailing truck wheels are compensated, which, in conjunction with the support at the four wheel bogie, forms the desirable three-point suspension system. The overhung laminated springs forming the compensated system, together with the springs of the leading bogie are manufactured from silico manganese steel, oil quenched. The spring gear anchorage at both ends of the rear spring system is provided with auxiliary coiled springs to cushion the dead or inactive points in the spring rigging.

Wheels.

The coupled wheels and trailing truck wheel centres are steel castings of the disc pattern. Provision is made in th

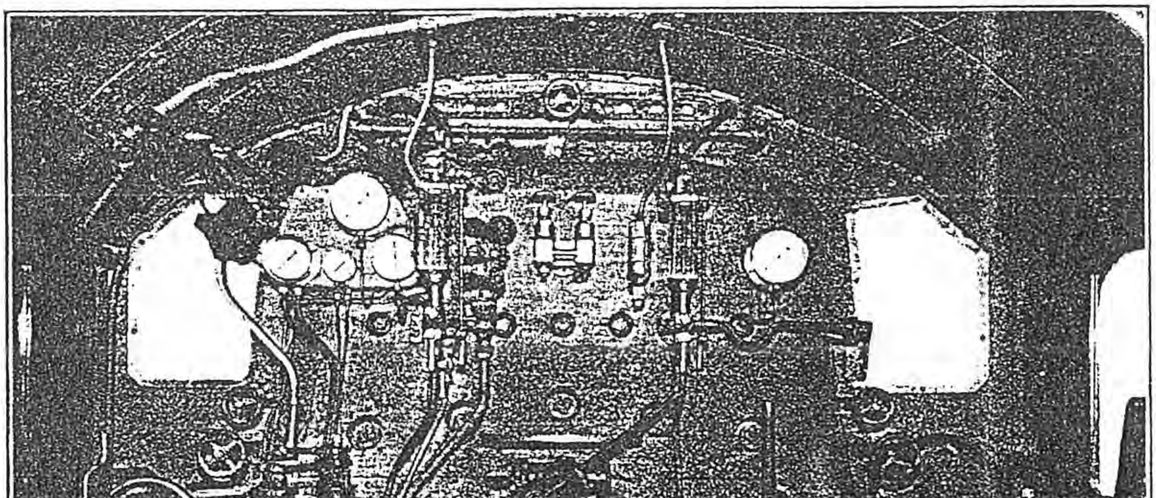

Fig. 9.—Showing Engine Cab Fittings.

pled wheel centres for cored balance weight pockets to accommodate the correct quantity of lead as determined by the dynamic balancing machine. All coupled wheels were revolved in this machine at the equivalent speed of 90 m.p.h., for final dynamic adjustment of the equivalent rotating weights acting at each crank pin.

The engine bogie wheels, trailing truck and tender bogie wheels, were also revolved in the machine at the same equivalent speed for correction of the slight out-of-balance which is inseparable from the manufacture of such components.

The tyres on the coupled wheels are secured by retaining plates riveted to the wheel centres and fitted into a machined groove in the tyre. The Gibson ring tyre fastening is used on other wheels.

The diameter of the driving wheels was fixed at 5 ft. 9 in., having regard to many factors, such as speed limits, grades, curves permissible, axle loads, existing 75 ft. turntables, and maximum rolling stock gauge.

An increase in wheel diameter would have increased the fixed wheel base and the distance between tubeplates, reduced boiler gas area or, alternatively, altered the trailing coupled spring to an underhung position ; increased the diameter of the cylinders, thus exceeding the gauge limit or, alternatively, necessitating a reduction in the distance between centres of cylinders and introducing eccentricity on the leading coupling rod, and so on.

The front engine bogie is the four-wheel equalised design, with one-piece steel casting frame, the bolster lateral displacement is controlled with a 40 per cent. constant resistance device. The two-wheel trailing truck frame is a one-piece steel casting of the "Delta" design, and the lateral movement is controlled with a ... per cent. resistance device.

Equipment.

Included in the locomotive auxiliaries is a six-feed Nathan mechanical lubricator, operated from the reversing link, which supplies oil atomized by an independent steam supply into the steam pipes, valve chambers, cylinders, and compressor, so that lubrication is supplied continuously while the locomotive is running either with the regulator open or shut.

An additional six-feed lubricator is used to lubricate axlebox guides of bogie and coupled wheels and slide bars, oil distributors being used to increase each feed from one to four.

A unit draw bar consisting of a draw and safety bar, together with radial buffing gear is used. The radial buffers provide the flexibility in every direction yet always maintaining normal contact between engine and tender.

Sand gear and cylinder drain valves are operated by air.

The steam chime whistle is fitted with an air control valve.

Special attention has been paid to the design of the cab so as to give good visibility to the enginemen.

Upholstered seats with back rests give comfort to the men, and the controls are within easy reach of the driver.

The staff exchanger is fitted to the tender and is immediately behind the driver's seat.

Westinghouse Air Brakes.

1. Compressed air for braking purposes and other services is provided by a cross compound air compressor having a capacity of 80 cu. ft. per minute.

2. A duplex compressor governor controls the compressor at high and low pressures as required. The high pressure governor is set at 120 lb. per sq. in. and the low pressure at 100 lb. per sq. in.

3. The main air reservoir is integral with locomotive bed and has a capacity of 30 cu. ft. It is divided into two portions, these being connected by a radiating pipe.

4. The air supplied to two 15 in. × 6½ in. stroke, VS type, brake cylinders, operates brake shoes on the coupled wheels of the locomotive, and two 12 in. × 8 in. stroke cylinders, AF type, operate the clasp brake shoes on the tender bogie wheels.

5. Complete and flexible control of locomotive and tender brakes is achieved by A6-ET type equipment with A6-P pedestal brake valve in the cab. Brakes may be applied and released partially or fully, independently of train brakes.

6. A hydrostatic control valve is incorporated in the tender equipment which permits of a brake cylinder pressure being obtained on tender, which is proportional to the weight of water carried in the tender tank, thus giving more even braking with full or nearly empty tender. Should the valve become defective in service, it can be isolated by means of a cover or change-over device.

7. An efficient hand brake is incorporated on the tender.

Recapitulation of New and Original Devices.

1. Belpaire ring connecting barrel of boiler to fire box.
2. Reversing or expansion link provided with increased travel to utilise precision feature of reversing gear.
3. Spherical bearing applied to small end of connecting rod to relieve stress on crosshead and associated parts.
4. Utilising the mass of the locomotive to counteract reciprocating disturbances, and thus prevent dynamic augment or hammer blows on the track.
5. Withdrawal sleeves applied to inside roller bearings to permit axle inspection, as is customary with ordinary friction bearings.
6. Elimination of dead or inactive points in main compensation gear, by providing spiral springs to take shocks.
7. Clasp brakes on tender.
8. Hydrostatic control valve on tender.

Allied Works Council.

Appointment of New Officers.

The Council of The Institution was very interested to read a press report stating that Mr. L. F. Loder, M.C.E., M.I.E.Aust., had been appointed Director-General of the Allied Works Council, as successor to Mr. E. G. Theodore who was due to retire at the end of October, 1944. The report further stated that Mr. L. J. Price, City Engineer of Brisbane, had been appointed an Assistant Director.

Mr. C. A. Hoy will continue in office as Assistant Director also.

It is very gratifying that Mr. Loder and Mr. Price, both Members of The Institution, have been selected, and the congratulations of The Institution are extended to them, together with best wishes for success in their new sphere of activity.

Mr. Loder, who is a Graduate of the University of Melbourne, joined the Country Roads Board in 1924, and four years later became Chief Engineer. He was appointed Chairman of the Board in 1940, following the death of Mr. W. T. B. McCormack, M.I.E.Aust. Mr. Loder has been active for many years in the affairs of The Institution, has held office as Chairman of the Melbourne Division Committee, and is a Councillor of The Institution.

Mr. Price obtained his degree as Master of Engineering in the University of Sydney. He resigned from the position of Engineer of the Municipality of Ku-ring-gai, to accept appointment as Engineer of the Greater Newcastle Council, in 1936. In 1940 he was appointed City Engineer of Brisbane. During recent years he has been seconded for duty with the Allied Works Council.

Meeting of The Institution.

Advance Notice.

The 101st Meeting of the Council of The Institution will be held at Sydney on Monday, the 27th November, 1944, commencing at 10.30 a.m. It is anticipated that the President of The Institution, Brigadier W. D. Chapman, will preside at this Meeting.

The 102nd Meeting of the Council will be held at Melbourne on Monday, the 19th March, 1945. On the evening of the same day the 25th Annual General Meeting of The Institution will be held at Kelvin Hall, 55 Collins Place, Melbourne, when the business of the Meeting will include—the presentation of the Annual Report of the Council and audited Statements of Account for the year ending 31/12/44; the declaration of the results of Divisional ballots for the election of Councillors for 1945; the presentation of the Presidential Address by Brigadier W. D. Chapman; and the installation of the President-Elect for 1945. (The nomination of the officer last mentioned will be made by the 101st Meeting of the Council in November). The 103rd Meeting of the Council, being the first Meeting of the Council for 1945, will be held at the same address on the morning of Tuesday, the 20th March.